SAFE BIND
SAFE FIND

The story of locks
bolts and bars

GARRY HOGG

SAFE BIND, SAFE FIND:
The Story of Locks, Bolts, and Bars
by GARRY HOGG

The Egyptians, and later the Romans, invented many of the locking devices which are still used today. The battle to keep valuables safe against those who are determined to steal them swayed first to one side and then to the other for thousands of years. It is the story on one hand of consummate craftsmanship and defensive skill, and on the other of the patience and ingenuity of the fingers that probed and exposed the secrets of locks and doors.

This volume tells also of the men who gave their names to various types of protection, only to be defeated in time by "pickers of the unpickable." And there are accounts of amazing robberies.

Because of the safecracker's uncanny skill, it is necessary to intercept him *before* he reaches the safe — so that bank vaults have become virtual fortresses.

All the elements of a suspense story are here in addition to the unusual information. The photographs and diagrams help to illuminate an enthralling story.

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The Story of Locks, Bolts and Bars

The first true locksmiths were blacksmiths. Etching by J. J. van der Vliet, 1635.

GARRY HOGG

SAFE BIND, SAFE FIND

The Story of Locks, Bolts and Bars

Illustrated with photographs and drawings

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NOTHING NEW UNDER THE SUN

THE YOUNG artist, son of an American locksmith, straightened up from over a vise in his father's workshop, a look of triumph on his face. He had just realized that he had solved a problem that had exercised the brains and ingenuity of locksmiths for four thousand years! This was: How to devise a lock that afforded maximum security, that occupied only a small area of the surface to which it was fitted, and that could be opened with a key no more than an inch or two in length and weighing only a fraction of an ounce.

His name was Linus Yale, Jr. The lock he had perfected was the famous Yale Cylinder Lock, which can be found today, a hundred years later, in its millions the world over, either with the name "Yale" stamped on it or with the name of some other lock-maker who has adopted and adapted the same basic principle of the "pin-tumbler."

Almost certainly there is a cylinder-type lock on your front door, and on the front door of almost every house on every street in the town. All that is visible from the outside is a brass disk an inch-and-three-quarters in diameter. In the lower half of the disk there is set another disk, some five-eighths of an inch in diameter; and set vertically in this small disk is a zigzag-shaped slot about two millimeters in thickness. A miniature version of this cylinder lock is to be seen on the instrument panel of any car, with the ignition key in it; a similar lock is fitted to one or both of the car's front doors, and also to the trunk. Certain makes of bicycle have miniature cylinder locks fitted to the shoulders of the front forks. Office doors, filing cabinets, document cabinets, lockers and hundreds of other such receptacles are almost universally equipped with this type of lock.

Why? The answer is simple. Though the cylinder lock does not offer the extremely high degree of security provided by the bank-type combination lock, it will resist any but the most determined lock-picking; and at the same time its key is so small, so light and thin, that a considerable number of them can easily be carried on a key ring or chain without their weight being felt. Many a businessman carries a key ring with Yale-type keys to fit the front door he closes behind him, the front door of his office, the lock on his private office, the lock to the cupboard containing the cigars and drinks he may have to offer to business associates, the lock on his locker at the golf club, and several other locks, on his car and elsewhere, that he may have to use in work and leisure hours. They are so small that they hardly make a bulge in his pocket; they occupy no more space than his lighter.

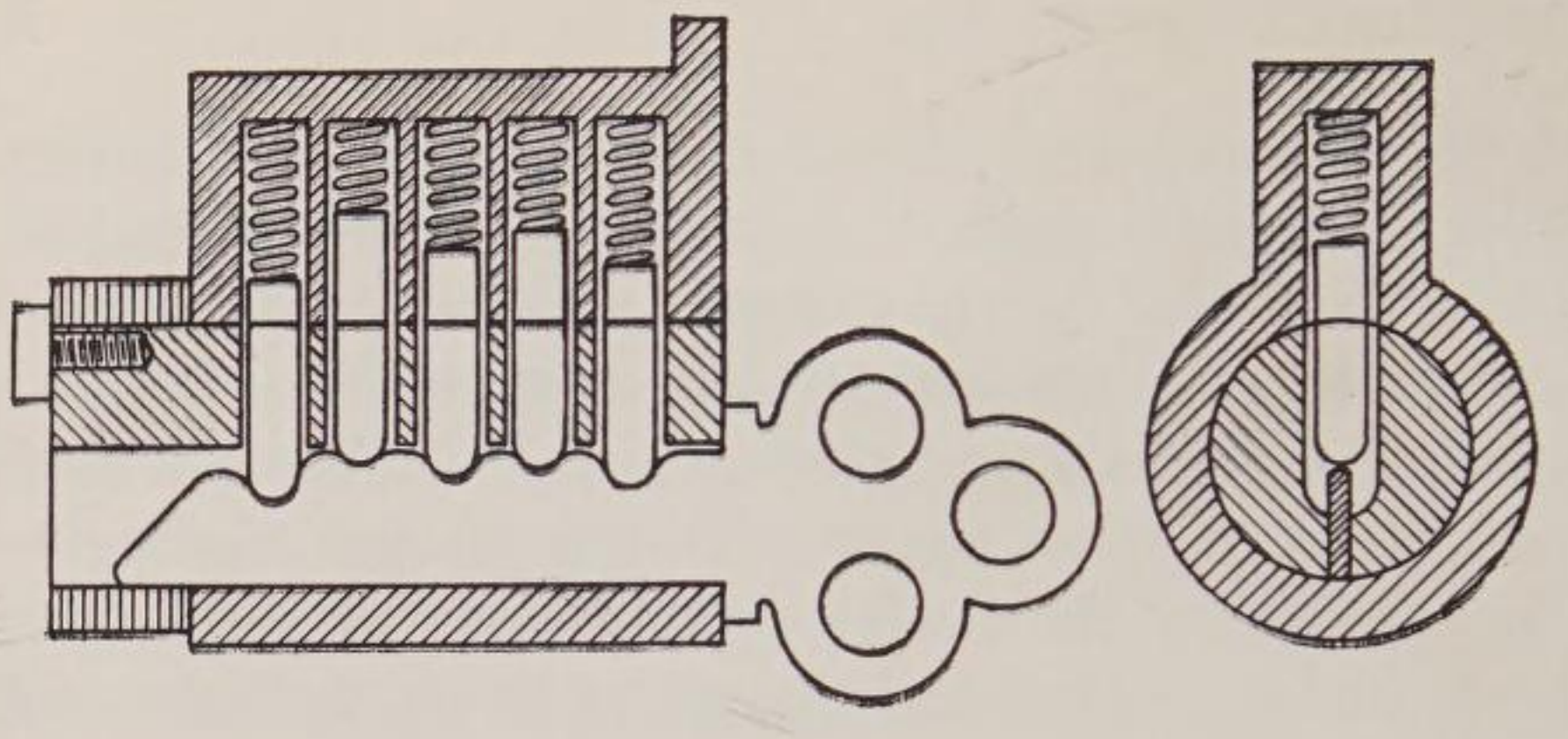
Linus Yale, Jr. had good reason to feel satisfied with his invention, or rather, with his refinement of his father's invention of a few years before. The gleaming object on his

work bench was a neat and satisfying little piece of machinery. Slipping the curiously shaped, flat and fluted key into the angular slot in the center of the smaller barrel eccentrically set in the larger barrel, he found that it turned smoothly, sweetly, silently, clockwise and counter-clockwise. Listening intently, he could hear the faintest whisper of movement behind the barrel as he thrust the key in, and then withdrew it. That was the secret of the cylinder lock: the pin-tumbler mechanism.

At first glance you might imagine that any thin piece of metal—a screwdriver blade, for example—could be inserted into the slot, or keyway, and so be capable of turning the cylinder barrel, or "plug," in the lower part of the main barrel, or "shell." You would be very wrong. For though what the locksmith calls the "detaining principle" of the Yale-type lock is very simple indeed it is at the same time exceedingly efficient. If you ever have an opportunity to look at a cylinder lock when it is dismantled you will at once see how true this is, and recognize it for the beautifully contrived little machine that it is.

The upper half of the main barrel has been drilled downwards from the top so that it contains a number of cylindrical slots, about one-eighth of an inch in diameter. These vertical slots are set close to one another, exactly in line, from near the face of the barrel back along its depth. Usually they number five in all, but there may sometimes be more. They are drilled vertically down until they penetrate the upper part of the plug that is set in the lower half of the barrel.

Each of the cylindrical slots contains a metal pin that fits closely to the walls, though not so closely that it cannot move up and down, like a miniature piston in a cylinder. This pin is known as the "tumbler." Above the tumbler there is a second metal pin, known as the "driver," which is



The principle of the Yale Cylinder lock, and of the ancient Egyptian "pin-tumbler" lock.

pressed down upon the tumbler by a small, finely tempered coil spring. Above the spring, the cylinder is sealed, so that the spring is in a permanent state of compression.

If you examine the pins carefully you will see that no two tumblers, and no two drivers, are exactly the same length, though the variation between them may be only a fraction of a millimeter. This is the secret of the security measure. For that fractional difference will be found to have its counterpart in the key that fits the lock. This consists of a flat, corrugated strip of metal, one of whose edges is smooth while the other is serrated, or saw-edged, having five or more teeth of irregular height evenly spaced along its length.

The operation of the key is simple, and foolproof. When it has been inserted into the keyway to exactly the right distance, as determined by the position of a shoulder, each of its teeth will be exactly beneath the tumbler with which it is intended to be in contact, and will have automatically lifted it, against the downward pressure of spring and driver, to exactly the point of junction between the shell and the plug that rotates inside it.

Until this junction between plug and shell has been cleared it is impossible for the plug to be rotated. And since

the plug carries an elongated strip of metal that engages in the bolt itself on the inner side of the door, this "cam" can only be turned, and the bolt be withdrawn, when the plug is rotated. The bolt itself is spring-loaded, so that it returns to the "shot" position as soon as the pressure on the key is released; that is why Yale-type locks when fitted to house doors have a knob to "catch" the bolt open when necessary.

You might imagine that the limit to the variations of height on a key's teeth would soon be reached, so that after a while each new lock and key would merely be a duplicate of one or more that had already been manufactured. In actual fact this is not so, for in a finely engineered piece of mechanism like a lock a variation no greater than the thickness of a piece of paper is sufficient, and this variation can be divided out among the tumblers and the drivers individually—ten items in all—working in differentiated pairs. You could collect the cylinder-lock keys from every house on every street in a whole large town, and it would be very surprising indeed if any two of them were even nearly identical.

As an additional measure of security, however, this type of lock does not rely solely on the minute variations of length in tumblers and drivers; the key, too, is an individually made object. The earliest Yale keys were simply flat strips of metal with serrated edges, but subsequent keys were made of corrugated, or fluted, metal. The "section" of each key would present a zigzag appearance, with a series of grooves of varying depth, varying width and varying angle, on each side, and bearing different relationships to one another. Only a key having the right section could even be inserted into the keyway in the plug; and only if it had the right arrangement of teeth would it raise the tumblers and so allow the plug to be rotated within the barrel, and the bolt therefore to be shot.

A cross-section view of the interior of a Yale-type lock

shows clearly the advantages of the refinement evolved by inserting a driver as well as a tumbler into each small cylindrical slot instead of having, as the prototype did, simply a single pin-tumbler. If the key tooth is too long, the driver is pushed upward against the compressed spring and the upper part of the tumbler follows it, so that part is in the shell and part still in the plug. If the tooth is not long enough, then the driver is not forced high enough to clear the junction between plug and shell, one part of it remaining below and one above the junction of the two. In either case the plug cannot be rotated, for it is locked in position by the obstruction. Linus Yale, Jr. in effect designed a double-acting tumbler; and as it happens, it is the double-acting tumbler, whether in a lever lock or in any other type of lock incorporating it, which has proved to offer the greatest degree of security.

One advantage of the cylinder lock is that it can be very easily fitted to a door, no matter what thickness it may be, and the same size of key—which is very rarely more than two inches long, and often considerably less—will always serve. The bolt mechanism, on the inside of the door, is actuated by a "cam," the elongated strip of metal that may be half an inch or six inches in length according to the thickness of the woodwork of the door, and the cam may be snipped off to the appropriate length with the utmost ease.

Linus Yale, Jr. may have had a smile on his face, a smile of triumph at having invented something new. In fact, however, he had only rediscovered the principle of the pin-tumbler lock invented by the Egyptians four thousand years before he was born! It was a secret that had been lost fo some forty centuries. Perhaps he did recognize the fact. In which case he may have said to himself, somewhat ruefully: "There's nothing new under the sun!"

2

PIN–TUMBLERS AND JANITORS

THE EARLIEST lock, of course, was the heavy stone rolled against the opening of a cave. When he went out hunting, primitive man left it in position, so that no wild animal could enter and harm his wife and children. When he returned, he moved the stone, went in and, if he feared intrusion, rolled the stone back into position behind him. It was a simple and fairly effective security measure—but obviously a clumsy one.

When mankind had no possessions other than a flint tool or two and a few crude utensils, it had little need for bolts and bars. But one aspect of civilization, however crude by today's standards, is the accumulation of personal property and effects. It may be a store of grain, or a hoard of gold

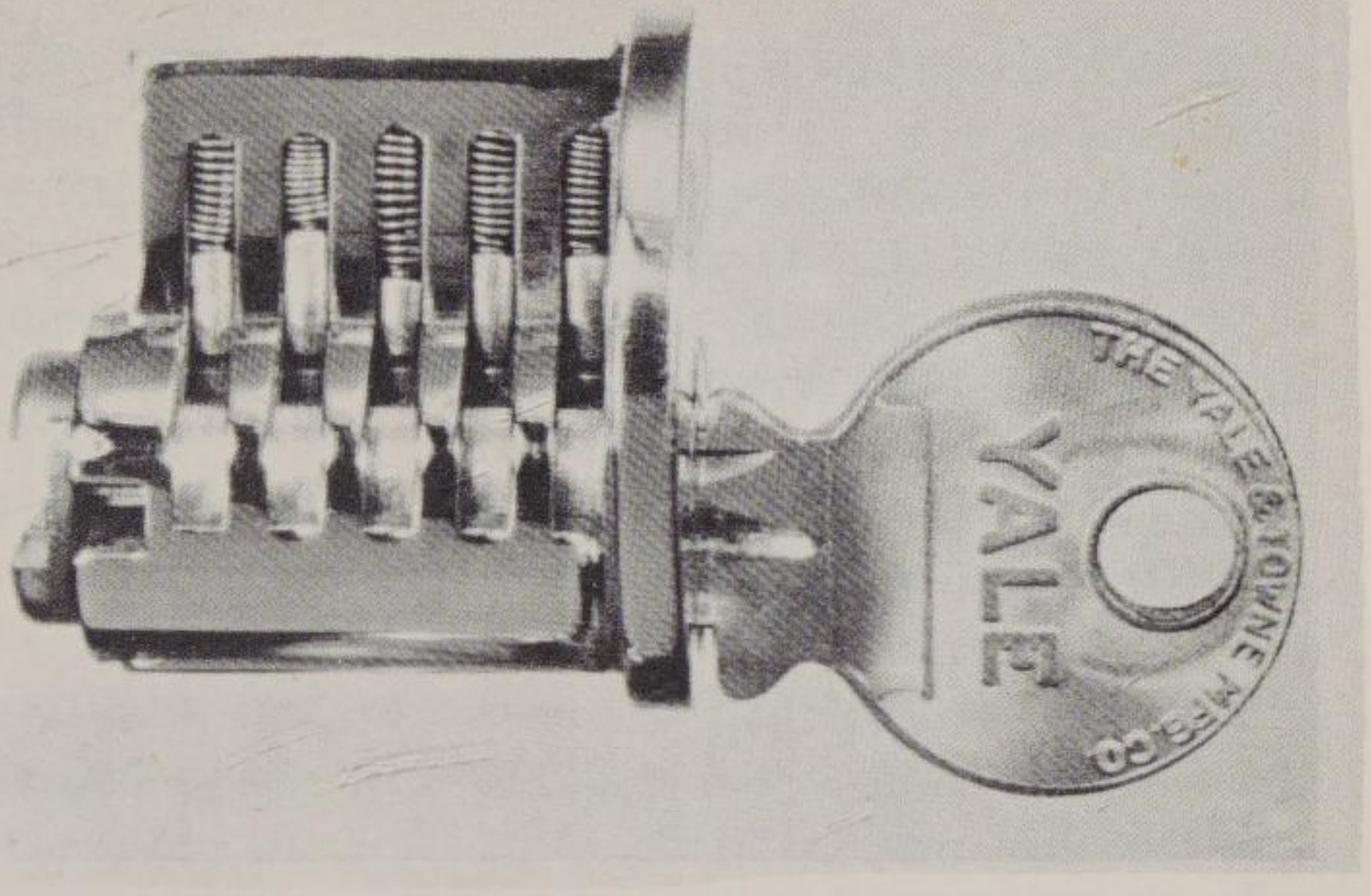
or other precious metal. When such property is known by others to exist it arouses cupidity. Therefore it must be made secure against predatory hands.

During long centuries in which most of Europe remained primitive and undeveloped, Egypt, on the other side of the Mediterranean, had developed an astonishingly high degree of civilization. Her buildings—notably the great pyramids—and her art and her scientific achievements, indeed her whole way of life, gave evidence of this. And it was in Egypt, forty centuries ago, that the first known examples of the true lock were to be found. Though it was made of wood, not metal and though it was, by comparison with modern locks, a cumbersome mechanism, it was ingenious and afforded an extremely high degree of security against unlawful entry. It was the world's first "pin-tumbler" lock.

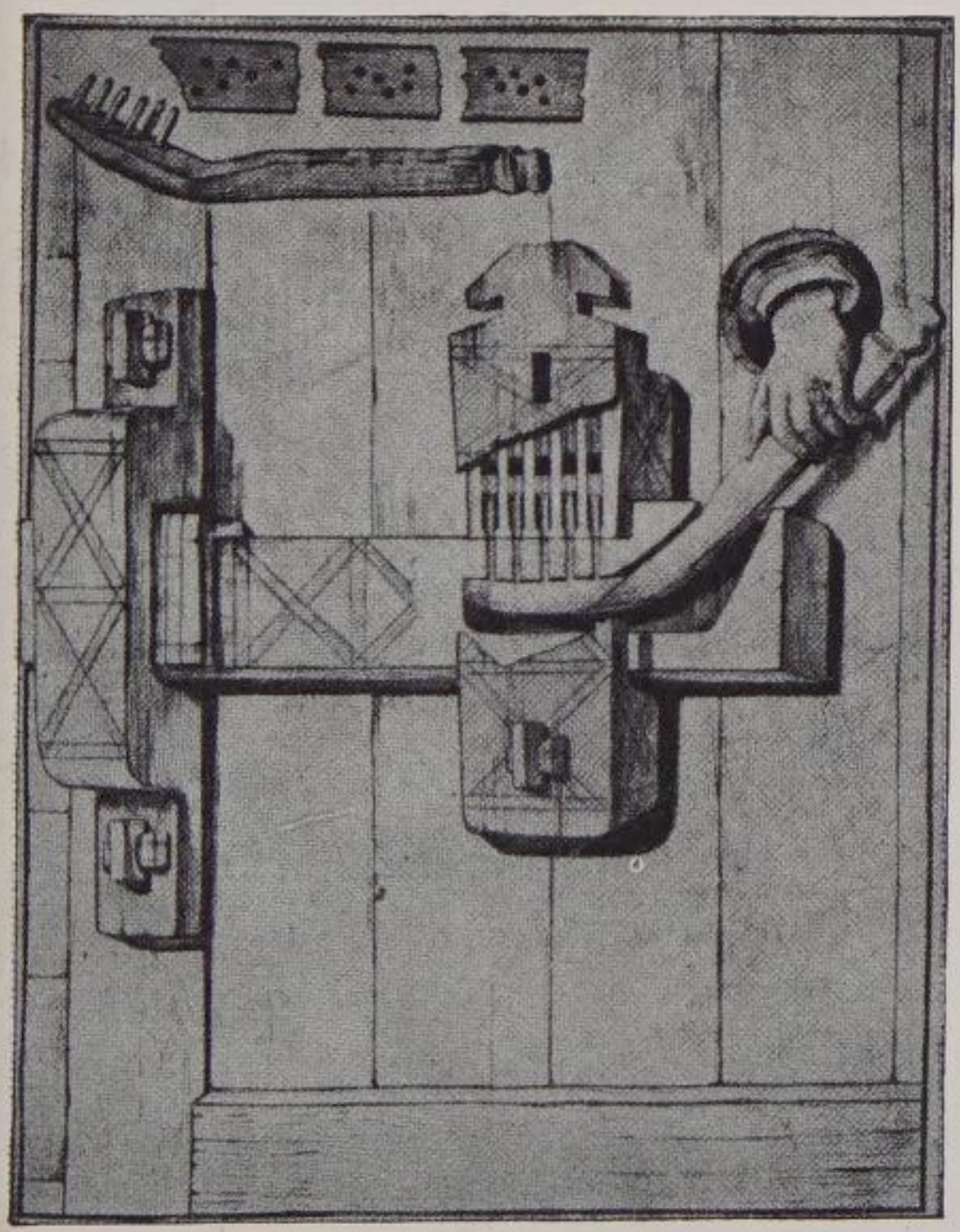
The Egyptian lock was fitted not, as in our day, to the inside of a door, but to the outside. Its main feature was a massive bar of teak or some other hardwood that could be slid sideways through a massive wooden staple until it passed either into a second massive staple fixed to the door-jamb, or into a square cavity in the door-jamb itself.

The curious thing about this Egyptian lock is that the locking mechanism was inside the bolt itself. The massive length of teak was hollowed out lengthways from the end farthest from the staples. This long interior groove—perhaps two or three feet in length—was the keyway into which a key had to be inserted in order to free the bolt and enable it to be withdrawn from the staple on the door-jamb.

How did the mechanism of the Egyptian lock operate? To discover this it is necessary to open up the staple attached to the door itself, which to all intents and purposes is simply another massive block of hardwood securely bolted to the timbers of the door. In fact, its appearance is deceptive. For inside the staple will be found a number of



Security for the householder in the twentieth century A.D. depends, as it did in Egypt about 2000 B.C., on the pin-tumbler lock. *Above*. A Yale lock in section showing how insertion of the proper key brings each tumbler and driver into line so that the cylindrical plug can be rotated.



Left. An Egyptian lock working on the same principle: only when the pin-tumblers have been pushed up by the pegs on the key can the bolt be moved.

cylindrical or square-cut slots: at least three in number, and sometimes as many as six or seven or more. They are not in line, but form an irregular pattern, not unlike that made by the dots on the face of a domino. In each slot is a wooden pin, or tumbler, so shaped that it can be moved freely up and down. Their weight keeps them normally at the bottom of their individual slots, a small shoulder, or collar, preventing them from falling out altogether. They protrude downwards for perhaps half an inch beyond the lower edges of the slots.

When the wooden bolt has been "shot"—that is to say, slid sideways until it has engaged with the door-jamb—these wooden pins have engaged with a matching set of holes in the upper face of the bolt concealed within the staple. So long as these pins are half in the staple and half in the bolt, it cannot be withdrawn; security is complete.

To withdraw the bolt, the appropriate key was necessary. The Egyptian key was utterly unlike any to be found today except in a museum. It resembled as much as anything an outsize toothbrush with a slightly curved handle of up to two or three feet in length. At one end were the bristles. These consisted of a number of pegs—three, four, five, six or more in all—set solid in the handle in a pattern exactly matching the pattern of the tumblers in the staple.

To withdraw the bolt it was necessary first to insert this long wooden key in the open end of the groove and thrust it sideways until it came up against a stop. At that point the wooden pegs were immediately beneath the pin-tumblers that were holding the bolt rigid, each peg matching the tumbler it was designed to engage. The key was then raised slightly. As it was raised, the individual pegs entered the lower end of the slots in the bolt, made contact with the tumblers and raised them in their own slots until they were clear of the upper edge of the bolt, which could

then be withdrawn by a simple sideways movement of the wooden key, whose pegs were still in its slots.

Obviously such a lock was difficult to pick, for its essential mechanism lay deep in the heart of the bolt, two or three feet from the opening that corresponded to our modern keyhole. On the other hand, there was an obvious disadvantage in having to use so large a key. It was cumbersome to carry about, difficult to hide from the prying eyes of someone who might be wanting to effect unlawful entry into the strong room it was intended to guard and who, if he was nimble-witted, might easily make a key of his own that was modeled on the other key.

An ingenious thief, for that matter, could effect an entry by a more subtle method—one which, like so much else that is ancient in origin, has been imitated by others for thousands of years. Once the principle of the pin-tumbler lock was grasped, all that was really necessary was to seize the opportunity to slide a curved piece of hardwood—a "toothbrush-blank," as it were—along the interior groove, having first coated its upper surface with a smear of wax or a thin layer of soft clay. Having reached the stop, this primitive but highly efficient form of key-blank would be carefully raised until it made contact with the pattern of slots in which the tumblers worked. The would-be thief had then only to withdraw his key, fit a set of pins to the pattern left in the wax, and he then had a duplicate key to use when the next opportunity occurred. The principle of taking wax impressions is at least four thousand years old and remains today one of the basic skills of the lockpicker and is one that remains effective in spite of all that the applied ingenuity of generations of locksmiths has thought up to baffle the burglar.

Many centuries later another nation, the Greeks, possessed wealth that had to be kept under lock and key. It is

possible that they learned the art of lock-making from the Egyptians, but certainly they evolved their own variant of the Egyptian lock. It was rather less complicated, but it possessed the great merit of being invisible from the outside of the building to which it was attached; they made use of the massive sliding bar-bolt, but it slid to and fro on the inside of the door.

When the Greek householder came home he faced a door with a small hole in it at about chest level and a foot or so from the door-jamb. Into this neat keyhole he inserted the point of his key and then gave the handle of the key a half turn, which automatically withdrew the bolt and enabled him to push open the door. Having entered, he closed the door, shot the bolt, and hung his key on a hook on the door-jamb.

He could not put his key into a fold of his robe, for it was far too large and awkwardly shaped for this, even though it was a good deal less massive than the Egyptian householder's key. In shape it somewhat resembled a sickle. It had a semicircular blade a foot or more in diameter and a fairly long handle. The blade, however, was not sharp-edged but round and tapering to a blunt point. The handle, especially if the key belonged to a man of wealth or rank, was often of rare beauty, for the Greeks took pride in adorning everyday objects, whether goblets, amphorae, columns or clothing. It was often delicately inlaid with gold or other precious metal; or it might be of solid ivory, carved into some design which at once gave it character and made it easy to grip. In a sense it was, like the automobile today, a form of status symbol; people judged the financial position and importance of the owner of a key according to its elaboration or the value of the materials with which it was decorated.

To open his door, the Greek householder inserted the

point of the blade into the hole in such a way that it engaged with a slot in the upper edge of the unseen bolt. By turning his wrist he could slide the bolt out of the staple on the door-jamb. The more massive the bolt, the stronger (and therefore the heavier) the key. It is small wonder that the wealthy householder assigned his key to a trusted slave, who accompanied him when he made his journeys to his warehouse, granary or storehouse and did the actual unlocking of the massive doors. The key would be carried with the curved blade over the shoulder and the ornamental handle prominently lying across the chest.

As with the Egyptian keys, so with the Greek keys, there was an essential weakness. A would-be thief had only to provide himself with a selection of these keys and there was a fair chance that one or other of them would fit the door he had it in mind to penetrate. Length and curve were easy enough to adjust; and there was no system of pin-tumblers to lock the bolt in position. It is a curious fact that the Greeks, fine thinkers that they were, did not evolve some additional safeguard that could be fitted to their sliding bolts.

Unlike either the Egyptians or the Greeks, the Roman artisans, being accustomed to working in iron and other metals, largely dispensed with the cumbersome bar-bolt and its equally cumbersome key. In their place they used something that was at the same time handier, more efficient, and more thief-proof. The Romans were the first locksmiths to realize a truth which every locksmith of modern times accepts as a vital principle: The smaller the keyhole, the less the likelihood of the lock being unlawfully picked.

They usually made their locks of iron. Unfortunately iron very quickly disintegrates after rusting has set in. Therefore it is rare indeed today to find any long-buried object that experts can positively declare to be a Roman-made lock.

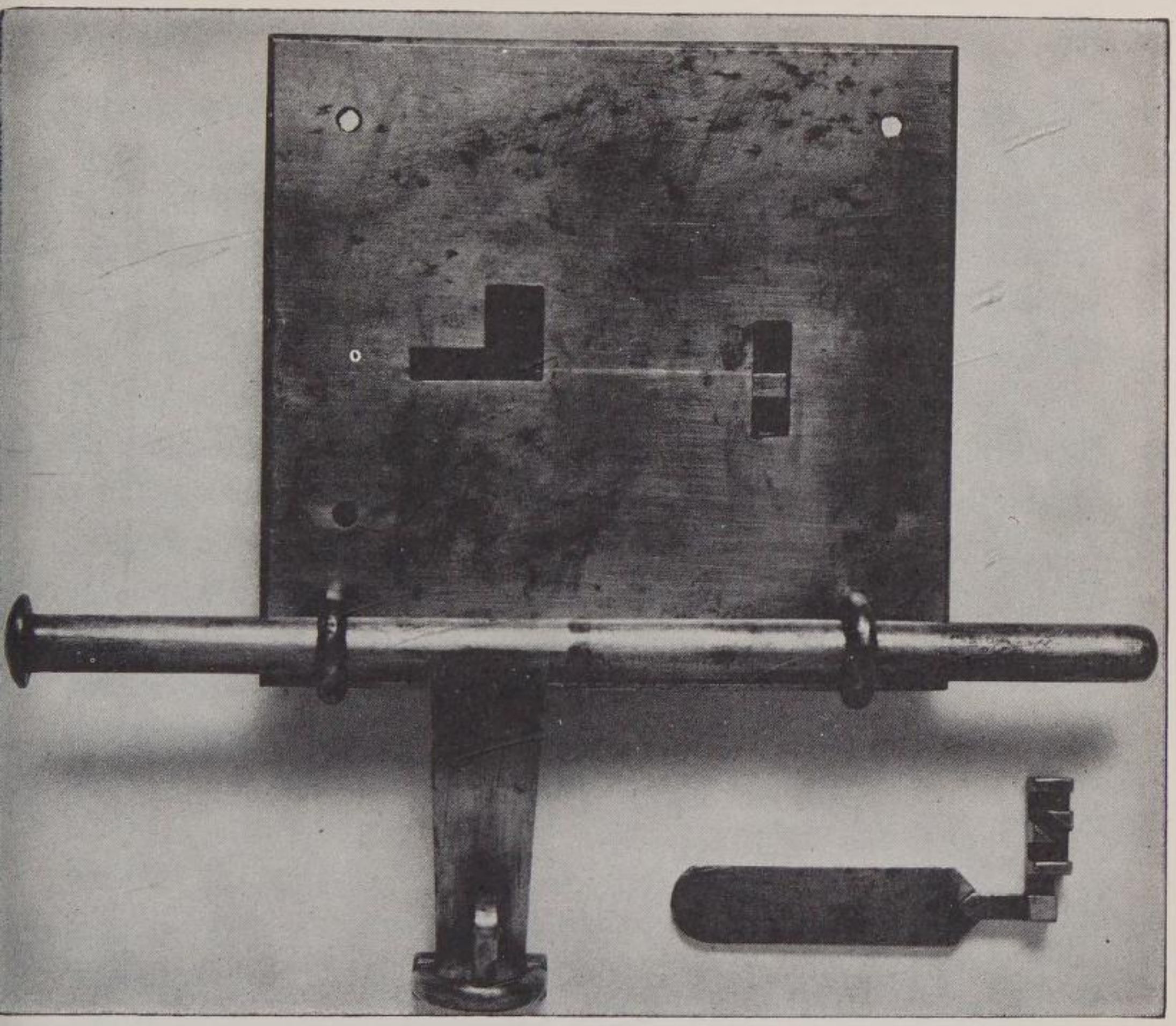
Fortunately, however, Roman keys were very often made of bronze—a metal that has an infinitely greater span of life even in conditions such as those of burial in chemical-impregnated earth.

One of the most profitable hunting grounds for Roman remains is the site of the ancient city of Pompeii, overwhelmed by the famous eruption of Vesuvius in 79 A.D. and buried in fine ash scores of feet in thickness. The catastrophe was so sudden, so complete, that the town was swiftly obliterated while its life was in full flow. As a result, archaeologists and others who have been excavating there for generations have unearthed innumerable articles and objects that were part of the way of life of the ordinary Roman citizen nearly nineteen centuries ago.

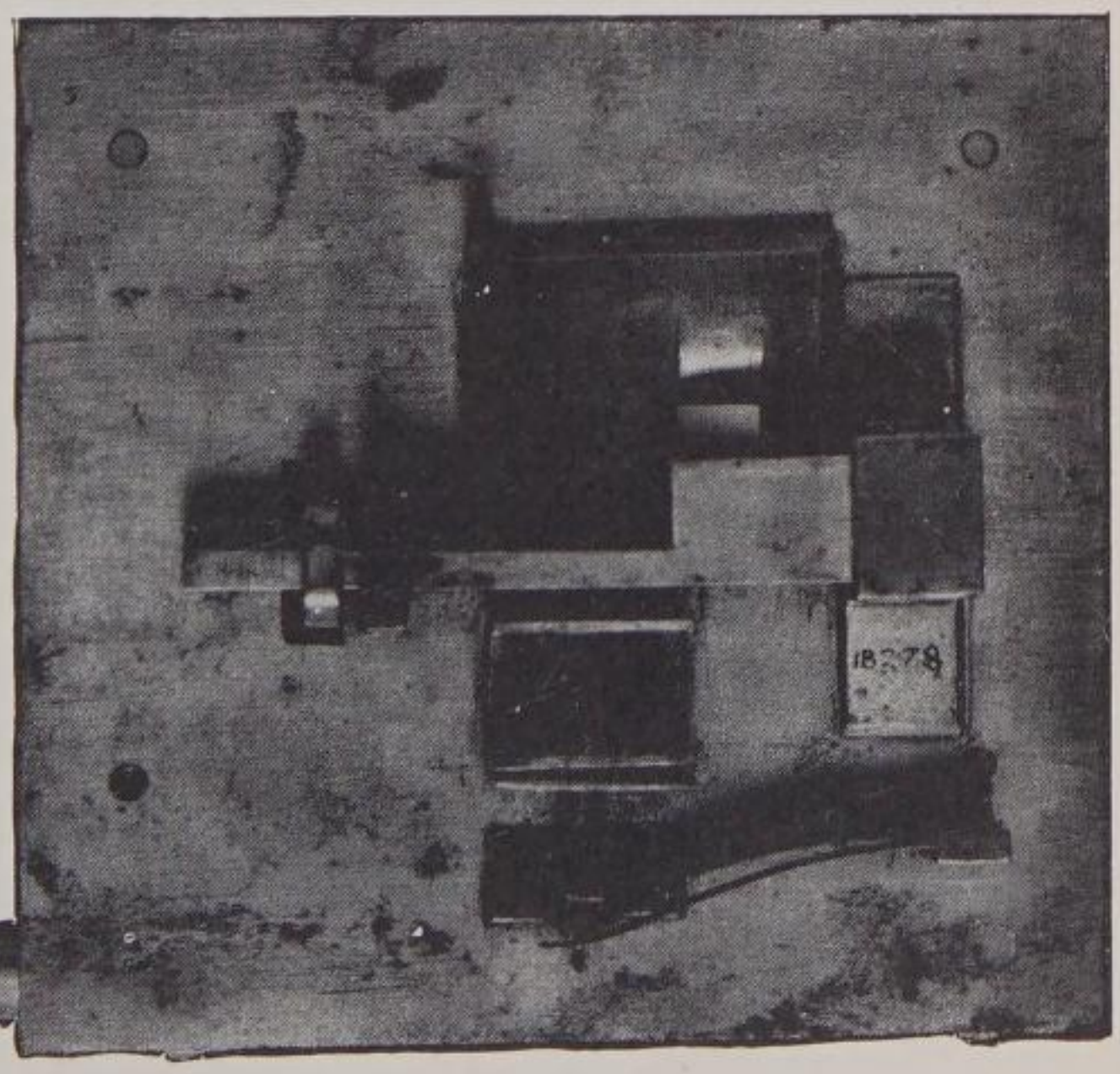
Among the innumerable articles large and small were a great number of bronze keys, and even a few made of iron, though these had disintegrated to such an extent that it took a real expert to identify them as such. Now it has always been a working principle among locksmiths that the key is designed and made first, and the lock made to match it. Thus it is possible to deduce from these keys something at least of the appearance and even the mechanism of the locks for which they were made, and of the principles on which they operated.

The shapes of most of the keys were extremely complex and intricate. They formed queer angles and zigzags, the metal of which they were made being contorted as though it had felt agony in being shaped by the blacksmith-locksmith. Many of them had a maze-like pattern of intersecting slits and slots, oddly shaped projections and equally oddly shaped hollows. It was quite evident that the locks they operated must have been extremely elaborate in their mechanism.

Some of the keys, however, were flat, with an elaborate



Model of a Roman lock, the original made of iron, in the Guildhall Museum. *Above*. The outside of the lock, with the key which operates the pin-tumbler mechanism. When the bolt is shot to the right the loop on the tongue of metal is lifted to fit through the rectangular hole. *Right*. The inside of the lock showing the loop on the outside bolt secured by the locking mechanism (left).



pattern cut into them. These, it was deduced, were designed to be inserted horizontally into a slot-shaped keyway and then moved laterally, shooting the bolt which had been freed of its locking mechanism. Others, however, were so shaped that it was evident to the expert eye that they had been designed to rotate within the lock, as the vast majority of keys do today. But there was a refinement of this piece of expert deduction; some of the keys found at Pompeii, and at Herculaneum (a second Roman city overwhelmed by the eruption of Vesuvius), were so shaped that it was evident that they were designed to rotate only part way in the lock, instead of completing the full circle. From this it was deduced that the Roman locksmith had invented the spring-loaded bolt, unknown before his time but nowadays the basic principle of almost every lock made!

The Roman locksmith was a first-rate craftsman. Where the Egyptian had had to use a key as long as a cane and very much heavier, and the Greek had had to use a key bigger than the average sickle, the Romans had keys small enough to be fitted to a finger-ring and capable of being enfolded in the palm of the hand unseen, while the ring could be shown and admired for the beauty of its workmanship and the quality of the metal and decoration on it.

One reason for the comparative smallness of the Roman key lies in the fact that their usual form of door-fastening was not, as with the Egyptians and the Greeks, a massive bar-bolt but rather something resembling the padlock as we know it today. The padlock was used either to join two short lengths of chain or to secure a hasp and staple linking door and door-jamb. From the few padlocks that have been preserved down the ages we can see that they were not unlike modern padlocks: circular, semi-circular, rectangular and strictly utilitarian. Occasionally, however, they had

been given some distinctive form, which shows that the Roman locksmith, like the medieval and later locksmiths, took pleasure in deploying his artistry as well as his craftsmanship and skill as a worker in metal.

All down the ages it has been a favorite practice among locksmiths—whether in Rome, in China, in Russia, in India, or elsewhere—to design padlocks in the form of animals or birds or fishes native to the country in which they lived and worked. A padlock might for instance be shaped like a cat, with a long, curving tail that rose over its back and whose tip entered a slot in the back of the head. Another padlock, perhaps the work of a Scandinavian locksmith, might be shaped like a reindeer, the hasp being a pair of miniature intertwining antlers that could only be separated by the use of the key.

All sorts of queer birds, beasts and even fishes provided the inspiration for these makers of padlocks, and there is no end to the ingenuity with which they adapted their raw material to this peculiar end. Certain creatures had a stronger appeal than others. The lobster and the crab, for example, were "naturals": what better symbol of security could be devised than those claws that could hold their prey with such a vise-like grip? The scorpion, too, was a popular subject; that dart of a tail which shoots up over its back and delivers its lightning stab was the inspiration for many a padlock hasp.

One of the most famous of all these ingenious padlocks inspired by something native to the country of the locksmith is known throughout the world as the Hindu Puzzle Lock. Its inspiration came from a bird, a mythical, fabulous bird which was the symbol of the Indian god of cunning and named Garuda. This Garuda-bird has an upstanding tail, something like that of a cock. Into this, the hasp of the padlock, swiveled from the back of the bird's neck,

securely fits. But there is much more to the padlock than this. Before it can be unfastened the keyhole has to be located, and this is difficult because the locksmith has most skillfully camouflaged it beneath one of the highly ornate wings. Nor can the wing itself be moved aside to reveal the keyhole until a secret spring has been located and pressed with exactly the right amount of weight. So, the Hindu Puzzle Lock is really a lock within a lock, affording a twofold measure of security against unlawful entry. It affords also a very fine example of the locksmith's combined ingenuity and artistry.

Not all Roman locks, however, were small and compact. With their leaning towards building on the giant scale—as at the Colosseum, for instance—the Romans occasionally demanded locks on the giant scale too; and to open these locks, keys of massive size and weight. Some keys unearthed in Pompeii were a couple of feet in length and weighed more than ten pounds, for bronze is a heavy metal. Naturally no patrician Roman householder would demean himself by carrying such a key. A slave was given this duty. He would be a slave whose integrity had been proved, who could safely be entrusted with this important responsibility. The slave's main task was to be on guard at the entrance to house or warehouse, keeping an eye both on the forum or street and on the interior and its valuable contents. The Romans had a god to whom doors and gates were dedicated: the twin-faced god, Janus. So, the door slave was known as a "janitor."

In the hands of a janitor, that two-foot, ten-pound key could be a useful weapon as well as a mere means of unfastening a locked door. If an intruder succeeded in obtaining entry, he could be felled, or even killed, with one shrewdly delivered blow from the key, which was worn on a loose chain around the janitor's waist. The Roman house-

holder must have been a suspicious type of person; often the janitor himself was chained to the door-jamb, as a watch-dog is chained to its kennel, the householder retaining the small key of the padlock-and-chain on his own person.

There is a curious parallel to this system of janitors to be found today in Madrid. In some of the residential districts the householder, instead of carrying his front-door key with him, entrusts it to a janitor. But this janitor is not installed in the house, like his ancient Roman counterpart. Rather, he is a sort of wandering night-watchman, who patrols the streets of his particular district armed with a huge ring, or chain, on which he carries the front-door keys for all the houses in his area. The chain, or ring, needs to be strong, too, for the keys it has to carry are not the small, pocketable, Yale-type keys but old-fashioned, wrought-iron keys often seven or eight inches long and weighing perhaps half a pound or more apiece.

How does this curiously archaic system work? The house-owner, let us say, returns to his house at two o'clock in the morning after an evening's entertainment with some friends —dinner in a hotel restaurant, perhaps, followed by hours of animated conversation over cigars and brandy. He arrives at his own front door. But instead of slipping a small, bright key into a keyhole, he stands on his doorstep and claps his hands loud and long.

After a little while a figure appears round the corner of the block, or at the end of the street, shuffling silently in felt slippers but jingling a formidable array of massive iron-mongery as he approaches. He is not hurrying, for he is probably very elderly, a man of known trustworthiness. As he comes close, he looks keenly at the man on the step, to assure himself that he is indeed the owner of the house and not some stranger hoping to deceive him and make unlawful

entry into the premises for some felonious purpose. When he is finally satisfied, he selects from his huge bunch of keys the one that he knows belongs to the ornate lock on the door, inserts it, turns it, and thrusts the door open for its owner to enter. Then—he pulls the door to after him and locks it again, thus making the householder a temporary prisoner in his own house.

It is a slow, laborious business. On a fine summer's night it may be pleasant enough to stand on one's doorstep until the street janitor with his massive armory of keys turns up in response to the traditional handclapping; but on a cold, wet night, when it happens that the janitor is at the far side of his district, out of hearing round the block, it may be necessary to wait quite a long time, while one's feet grow cold, the rain soaks through one's overcoat, and the slow, dark minutes tick tediously by. To the stranger visiting Madrid for the first time, this continuous handclapping and the resultant jingling of heavy keys provide one of the less pleasant experiences; so long as this comically antiquated custom persists it is only the very sound sleeper who can count on an unbroken night from dusk till dawn.

TREASURE–CHESTS

IN THE DAYS of the Robber Barons, when might was right and wealth accumulated in the castles of the men powerful enough to win and keep it at their neighbors' expense, the necessity for some means of securing valuables became increasingly acute. There were of course no banks or strong rooms or safe-deposits in those dark days; a rich man kept his wealth close at hand, where he could watch over it personally. Or he might sometimes entrust his secret to an elderly retainer who would watch over it as though it were his own, knowing that a moment's carelessness would mean for him a painful form of death.

Valuables were stored in chests; the greater their value, the heavier, more substantial, the treasure-chest. It might

be made of oak planks; it might even be a solid baulk of oak hollowed out with chisels and fire into the form of a chest. In either case it would be lavishly bonded with heavy iron straps, often woven or plaited so closely that it was almost impossible to detect the timber beneath them. Great hand-wrought iron studs would be driven in at the intersections of the straps, so that the treasure-chest bristled with obstacles.

Nevertheless a treasure-chest had to be capable of being opened; and it was naturally in its mode of opening that its inherent weakness lay. However solid the timber, however close-set the iron straps, the lid must be hinged if the lawful owner was to be able to get at the contents. And if the owner could get at them, then there was always the chance that someone else might be able to effect unlawful entry. This of course has been the perpetual problem of property owners, and of the locksmiths working on their behalf, ever since men began to accumulate wealth for themselves—a very long time ago!

It was through this unceasing effort to make treasure-chests more and more impregnable that the lock and key have developed into what we are familiar with today.

What, in essence, is a lock? And what is a key? A lock consists of a mechanism, more or less elaborate, contained within a flat case, usually but not invariably rectangular (or, in the Yale type, cylindrical). Its chief element is a bolt of varying size that can be "shot" into a staple or other recess and be held there rigidly until it is required to be withdrawn. A key, whatever shape it may have been given, is simply a device for operating the mechanism within the lock in such a way as to actuate the bolt.

Some genius—it may well have been a Roman craftsman, but it is not possible to be certain about this—first devised the principle of the "ward": a hidden device for frustrating

the movement of any key in a lock unless it was the one expressly made for that lock. After the principle of the Egyptian pin-tumbler lock had faded into oblivion (to be revived four thousand years later by Linus Yale, Jr.) the warded lock became the only reliable security measure known to man. It held sway for centuries, until it was superseded in comparatively recent times by the "lever" lock (with which it is sometimes incorporated) and, later, by the mathematically contrived "combination" lock.

An easy way to grasp the principle of the warded lock is to detach almost any indoor lock from the door, unscrew the back-plate and take a look inside. In all probability it will be a very simple lock indeed; it may have a single lever, but it will almost certainly be warded.

Fitted inside the lock will be found a series of raised metal strips set in a circle round the keyhole, its center being the "O" of the keyhole, which receives the end of the key stem. The concentric strips of metal will form a circle that is complete except for the slot beneath the "O" of the keyhole, through which the key passes when it is inserted into the lock. This raised circular obstruction is designed to prevent the rotation of any key other than one that has been shaped to pass over the wards. Until it has passed the wards it cannot make contact with the mechanism that actuates the bolt, and the bolt, therefore, can neither be shot nor be withdrawn.

A key consists of three essential parts. There is the "stem," which will be hollow for part of its length if the key is a "pipe" key designed to fit over a pin inside the lock, or solid if, like the majority of keys, its tip, or "pin," is simply intended to pass through the "O" of the keyhole and a second "O" on the other side of the lock. At one end of the stem there is the "bow," which is usually oval or trefoil-shaped, but may be rectangular or round or indeed almost any

shape. And at the other end, the "working" end, there is the key's "bit," the most complicated and important part of any key.

All key bits are basically rectangular, but two or three of their sides are cut in an enormous variety of ways into wards corresponding to those within the lock which is to be actuated by the individual key. The edge of the bit running parallel with the stem will probably be cut into a series of "steps," the one nearest the tip being the "bolt step," or "terminal step": the one which actually engages with the bolt and moves it to and fro as the key is rotated clockwise or counter-clockwise. The steps on the other two sides of the key have nothing to do with the actuating of the bolt, but determine whether or not the key will successfully pass the wards of the lock. If the key is to be used on one side of a door only, then these ward steps will be cut only on one of the two remaining sides of the bit.

Even a cheap, simply shaped lock and key possesses a curious fascination. It has something in common with any miniature machine, such as the model locomotive. It is a machine because it has working parts that operate in unison, require occasional lubrication if they are not to show signs of wear, and depend upon the right application of an essential factor, in this case the key.

A look at some of the locks designed and constructed in the Middle Ages—whether in Britain, France, Germany or elsewhere—reveals that the earliest locksmiths were as fascinated by the problems with which they were confronted as people are in today's scientific age when confronted by the miracles of modern inventiveness. Their basic problem was, of course, to present the would-be thief with the maximum degree of obstacle to the opening of a lock.

The medieval locksmith entrusted with the task of de-

signing and constructing a baron's treasure-chest or an ecclesiastical chest to contain the church's rare altar plate sought the answer to his problem in elaboration and multiplication. If one lock is safe, he said to himself in effect, then six locks will be six times as safe, and twelve locks twice as safe as six locks.

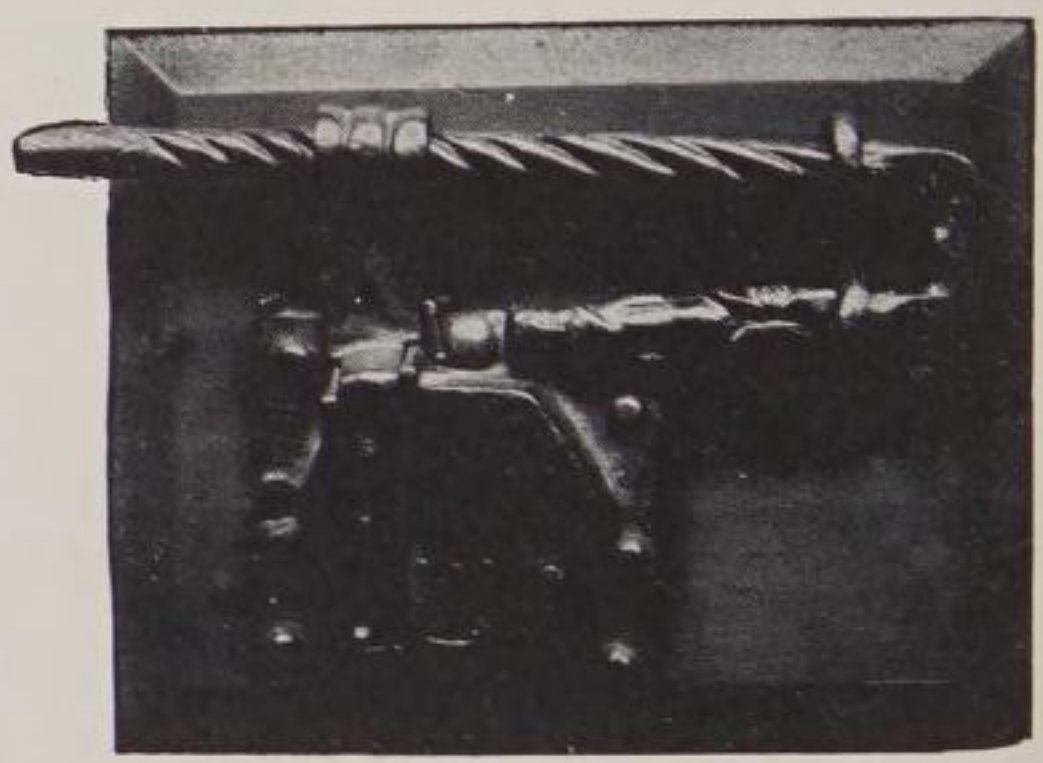
The result was that in many of these medieval craftsmen's treasure-chests the whole of the interior of the lid consisted of nothing but an infinitely elaborate locking mechanism. The chest might have six or eight or ten or even a dozen individual bolts, which could be simultaneously shot outwards in such a way that they engaged their individual slots carved out of the solid sides of the chest, perhaps four in front, two in the hinged side, and three in each end. The shooting of ten or twelve massive bolts thus converted the whole chest into one virtually impregnable unit.

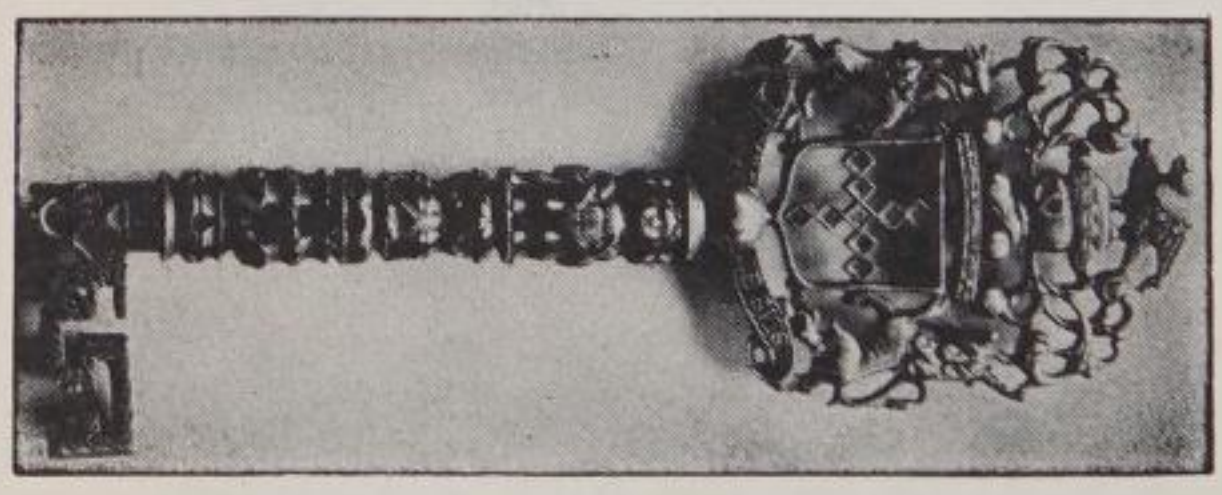
Impregnable? No—because the locksmith, with his passion for multiplication, had overlooked the fact that though there might be up to twelve bolts, all of them were actuated by one single key, rotating in one single keyhole! If the would-be thief could insert a makeshift key into that keyhole, then he could withdraw all twelve bolts as easily as if there were only one.

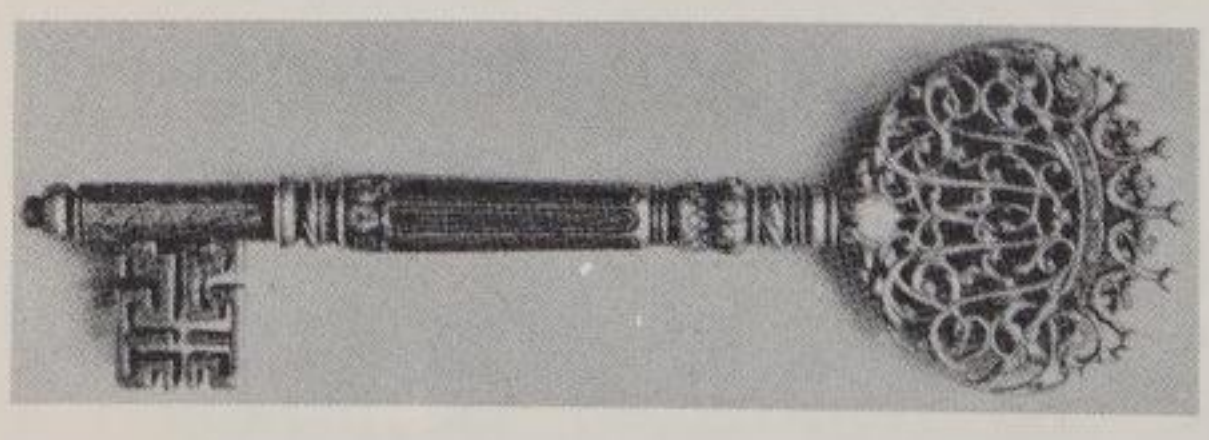
The chests, and their locks, designed and constructed in the Middle Ages are notable just as much for their elaborate ornamentation as for the complexity of their mechanisms. No craftsmen, probably, at any time in history have taken more pride in the sheer appearance of their products than the medieval craftsmen did; and there are certainly few articles essentially designed and constructed for purely utilitarian purposes that have had as much sheer artistry lavished upon them as locks and keys have had.

A locksmith would spend not merely days or even weeks, but months on the perfecting of a new and elaborate lock-

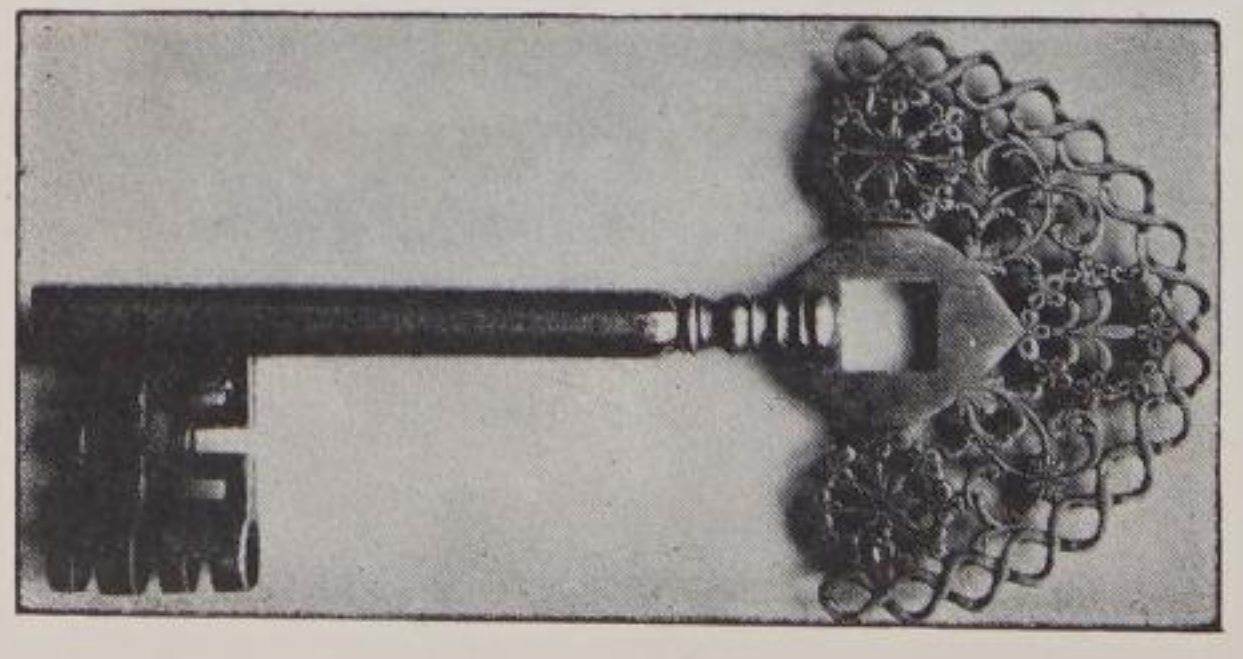
Above left. Wrought-iron bolt of the early sixteenth century.
Above right. Hammered-iron bolt decorated with the monograms of Henri II and Anne de Montmorency; middle sixteenth century.
Right. Lock with decorated bolt, made of wrought iron; fifteenth century.







Very decorative English keys of the seventeenth and eighteenth centuries; chiseled steel.

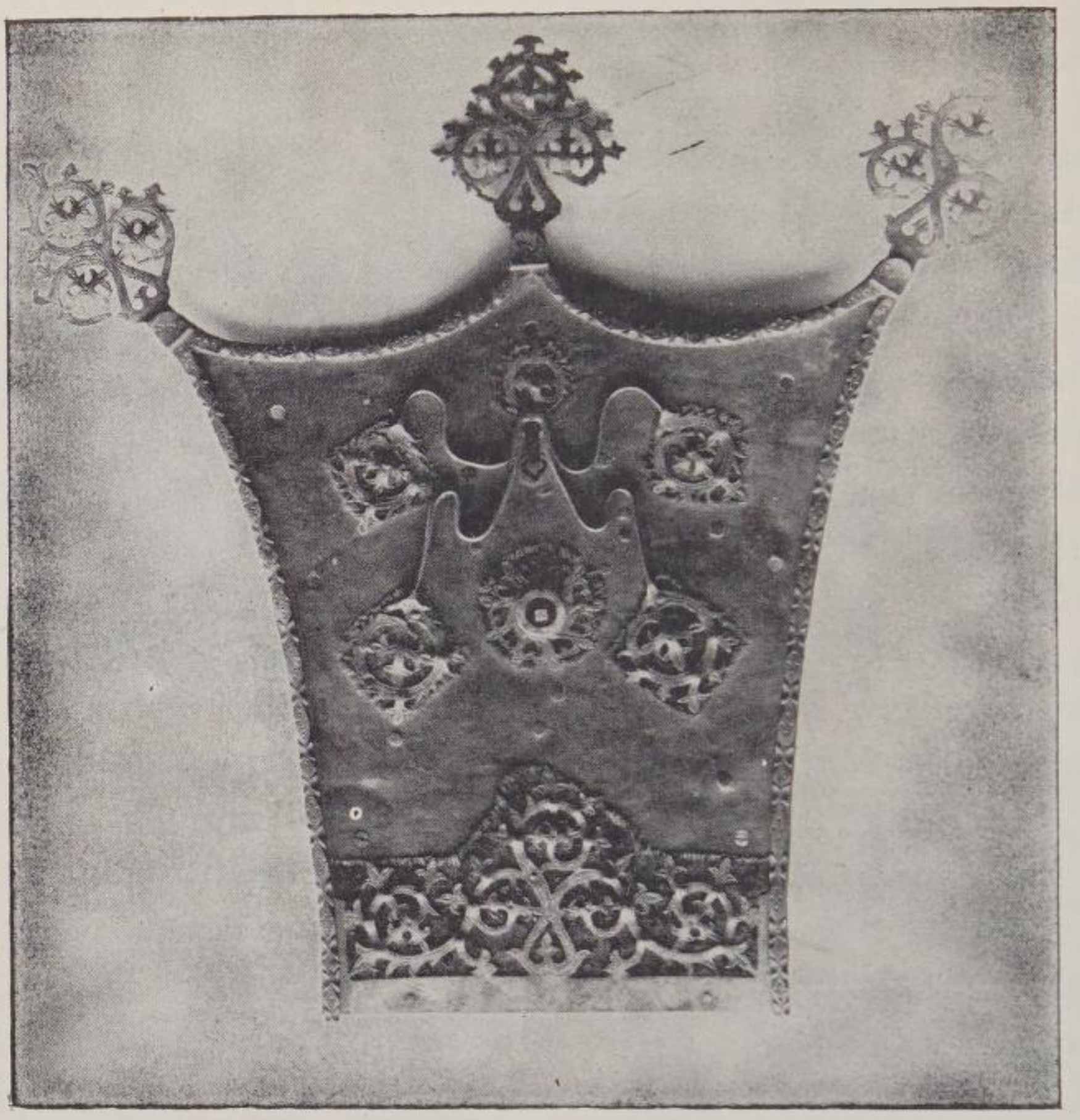


ing device, and on making the outward appearance of the whole worthy of the intricacy and efficiency of the mechanism. Many of these medieval locks have been preserved and may be seen today in private collections and museums. They are objects of rare and satisfying beauty: creations by craftsmen who delighted in the opportunities they had to carry out the finest possible work.

One of these "masterpiece" locks, as they are sometimes called, was not long ago carefully dismantled piece by piece by expert modern craftsmen; each individual piece of metal, down to the last screw and bolt, was minutely inspected under a powerful magnifying-glass, its shape, weight, proportions analyzed and assessed. So elaborate and intricate was the design, so meticulously accurate the machining, so beautiful the decoration, so perfect the whole conception, that the experts came to the conclusion that the lock represented no less than *three thousand* hours of a locksmith's time! That represents ten hours' work for every working-day throughout the greater part of a year.

Strangely enough, a "masterpiece" lock may well have been made, not by a man who had been a locksmith all his life, but by an apprentice to the trade. In the days of the trade guilds an apprentice had to serve ten years before his locksmith master held that he could claim to be fully qualified. One condition of his qualification was that he should design and construct an outstanding lock and key. These would be minutely inspected by veteran members of the Locksmiths' Guild, and only if they were flawless would the apprentice be permitted to pass into the next grade and call himself a "journeyman."

When locksmiths came to recognize the essential weakness in a chest that had a number of bolts all actuated by a single key, the obvious alternative was to duplicate not merely the bolts but the locks themselves. This of course



A richly ornamented chest lock made of iron; German, late fifteenth century. The skill of the locksmith at this period was applied as much to intricate decoration as to the locking mechanism itself.

A modern copy of a chiseled iron lock of French workmanship, also of the fifteenth century.

meant duplicating the keyholes in the lid, and it was here that their passion for elaboration of ornamentation stood them in good stead. It was no longer necessary to have one large keyhole, to take one large key strong enough to operate the mechanism of a number of massive bolts. Instead, it would now be possible to use several small keys, each with its own small, unobtrusive keyhole, but each strong enough to operate its own individual lock. Two, three, even four small keys might be used in such a chest; and since the keyholes would be correspondingly small it would now be possible to make use of the ornamentation to camouflage them.

So, more and more elaborately patterned metalwork was designed. It would be shaped in elaborate scrolls, in ornate foliage of exotic trees and shrubs, sometimes with birds in their branches and animals wandering about among their stems. A really imaginative artist-craftsman might actually create his own birds and animals, modeling them on the strange tales he had heard travelers tell on their return from distant parts. He would design gryphons and dodos and dragons and mandrakes, phoenix and roc and half a hundred other fabulous creatures that might serve his purpose by concealing in their eyes, or beneath their wings or in the folds of their shaggy hides the small, intricate keyholes of which the owner of the treasure-chest (and the craftsman himself) alone possessed the secret.

Or, as a gesture to his important, wealthy and perhaps noble patron, the locksmith might incorporate in his metalwork the owner's coat of arms, or some other heraldic device. This would afford him ample opportunity for concealing the keyholes. And such a device was appropriate, too; after all, shields were the symbol of security on the field of battle, or in joust or tournament. How better conceal a keyhole from the would-be thief than by placing over it

a miniature shield, or coat of arms, that had to be moved aside before the keyhole was revealed? Even today, eight centuries or so later, the sliding panel that conceals the keyhole of many expensive strong-boxes, and may in fact have its own miniature keyhole to take a minute but complex key, is known as the "escutcheon," and the lock itself as an "escutcheon lock."

The escutcheon was often nothing more than a shield, or a plate bearing a heraldic device or coat of arms; sometimes, however, it was so elaborate that it disguised itself. For example, one well-known masterpiece lock bears the appearance of a model house-front. It has a door in the center, with an ornate portico around and above it; the portico is flanked on each side by windows consisting of exquisitely beautiful polished steel scrollwork. The whole lock, in fact, nine inches or so in length, is of highly polished steel. It possesses four bolts, obviously not just ornaments. But of the existence of a keyhole there is no sign whatsoever.

To open this lock it is necessary first to locate a small, concealed, finely tempered spring. This, when exactly the right amount of pressure is applied to it, causes the left-hand scrollwork "window" to open outwards on invisible hinges. Behind the window there are to be found the knobs of the four bolts, to which again exactly the right amount of pressure has to be applied before the bolts can be shot. Once shot, they are immovable, and no amount of tinkering with their innocent-looking knobs will withdraw them.

It is now necessary to examine minutely the center panel, consisting of an elaborate shield, supported over some scrollwork by a lion and a unicorn and in turn surmounted by a crown, as in the royal coat of arms. On each side of the panel is a fluted column, with its own capital; and above that a beautifully proportioned pair of curved architectural

wings to knit the whole together and form the portico effect.

Somewhere concealed in the elaboration of this center panel is a second minute and delicately tempered spring. This, too, must be located and then depressed, neither too hard nor too gently. When the correct degree of pressure is applied to it, the "door" of the portico, the coat of arms, lion, unicorn, and crown all open downwards from an invisible hinge in the scrollwork along the "doorstep." Behind this there is a keyhole.

When the key is inserted into this keyhole, and rotated, it withdraws the four bolts that have been shot from behind the left-hand panel of the lock. When the key has been removed, the "door" can be closed again, and then to all intents and purposes there remains simply a little model house. The right-hand "window" is a dummy, matching the scrollwork of the left-hand one and so giving symmetry to the whole; it serves an additional purpose, however, in confronting the would-be intruder with the further problem of how and where to locate the opening mechanism which his common sense tells him must be concealed behind one or other or all three of the main features of the lock.

It was not only the lock that received the imaginative attention of the medieval locksmith; the key, too, had to be ornate and beautiful as well as efficient. The key to this particular lock happens to be among the most elaborate and intricate ever designed. By today's standards it is large, being some six inches in length, although it is small in comparison with those designed by the earlier medieval locksmiths. In fact it consists of a key within a key. The inner stem carries the bit, but can itself be rotated within an outer, hollow stem, square in section and most ingeniously carved to resemble a miniature wrought-iron lantern. By

means of a decorated knob the inner stem can be rotated, and as it turns it can be seen that it consists of a series of elaborate spirals which glint as they move and form moving kaleidoscopic patterns behind the open work of the outer stem.

The most remarkable feature of this key, however, is the bit. This, in spite of the overall length of the key, is small, being no more than five-eighths of an inch square. This small square—about half the size of a postage-stamp—contains no fewer than seventeen fine saw-cuts and sixteen fine "vanes" separating them. What sort of a chisel, saw or file can have been used to make so many parallel saw-cuts in so small an area? And what miracle of steadiness of hand, keenness of eye and sheer protracted patience made this patterning of the key-bit possible?

Nor are the saw-cuts and vanes the only wards on this superlatively patterned key. Between the cuts and vanes and the pin of the key there are no fewer than twelve minute square holes, in three rows, each hole separated from its neighbour by more of these fine saw-cuts. To examine such a key is to realize why the key-bits used to be referred to as "webs"; in this particular case the web resembles a comb with the finest imaginable teeth. Yet it is made of steel. And in the interior of the lock is a set of wards exactly matching the delicate tracery of saw-cut and vane of the key. If, as is possible, this particular masterpiece lock was the work of a locksmith's apprentice, then it is to be hoped that it earned him his diploma!

Compared with many of the locks designed and constructed by these old locksmiths, this one was a baby—a mere nine inches in length. Its date, as a matter of fact, is just a little later than the period known as the Middle Ages, and it has no name. But many of these old locks do have names, and histories, too. One of these, made about a

Above. A large French chest lock of the fifteenth century, made of iron. The keyhole is under the hinged part of the central panel.

Below. The Beddington lock, an English lock of the early sixteenth century. The Royal arms conceal the keyhole. Henry VIII is said to have taken this lock with him wherever he went and to have had it screwed to his bedroom door.

century earlier, for instance, is known as the Beddington lock.

It is a giant by comparison: fourteen inches long, more than half that in width, and proportionately thick, with a giant of a key. It is a wrought-iron lock, overlaid with gilt, and its ornamentation tells part at any rate of its history, for it includes the Royal Arms used by both Henry VII and Henry VIII. It was the work of the Royal or Palace Locksmith, and the two monarchs attached great importance to it. It represented their own personal security. Whenever they went on a royal tour through their domain they took the Beddington Lock with them, and insisted on having it fixed to the door of the apartment set aside by their temporary host for their overnight accommodation. Perhaps if King Duncan, several centuries earlier, had possessed a "Beddington" lock, and had had the forethought to have it fixed to his bedroom door in Macbeth's castle at Dunsinane, he might have escaped being murdered in his sleep.

An even larger lock, no less than twenty inches long by twelve in width, and proportionately thick, required the use of two differently cut keys and two separate keyholes, plus the use of a stiletto. Like many of the locks from the Middle Ages onwards well into the eighteenth century, it was decorated with an extremely elaborate pattern of metalwork —scrolls, foliage and curlicues of the most fantastic kind. However carefully you examine this ornamentation, even if you use a magnifying glass, you are unlikely to spot the keyholes. There is, however, a microscopic pinhole which looks at first as though it is just part of the pattern of dots that make up much of the detail decoration.

It is large enough, though, to take the point of a keen stiletto. When the stiletto has penetrated far enough it engages with a fine concealed spring; this releases a small escutcheon, pivots a few degrees, and in so doing reveals

a keyhole. Into this the larger of the two keys is inserted. The key has to be rotated not one complete revolution but two, and at the end of the second it causes two massive bolts to slide in or out of the door-jamb. For additional security, however, a third bolt, this time a spring-loaded one, can be shot. To effect this, the second keyhole must be located—again by the insertion of a stiletto point into an almost invisible hole. The smaller key functions in this second keyhole, actuating the third bolt. This use of dual, unmatched keys was simply one of the innumerable devices worked out and put into practice by the older locksmiths in their attempts to find guaranteed security for the treasure-chests and storehouse doors which they were called upon to design and construct. To examine their products in the show-cases of some museum is to realize that there is virtually no limit to the ingenuity of which they proved themselves capable.

4

SNAPPING JAWS AND SKELETONS

A PRETTY good measure of security was about all that the medieval locksmiths could hope to offer their clients. For several hundred years they exercised their wits and ingenuity on the problem with which they were confronted: the problem of safeguarding valuables against unlawful entry. Those long centuries were the heyday of the warded lock.

But however great their ingenuity, however elaborate and intricate their locks, however massive the chests of which they formed an integral part, thieves seemed eventually to find means of circumventing the locksmiths' skill. This hurt their pride as much as the thefts angered the owners of the valuables. Something, obviously, had to be done about the problem; and it is clear from the records that many lively

minds were at work upon it. These were the minds not only of professional locksmiths but of intelligent men who, though they were not craftsmen and had had no training at the bench, nevertheless were endowed with keen imaginations and a flair for invention.

The Marquis of Worcester was one of these. Writing soon after the death of Shakespeare, he put forward a number of "Inventions" which, he held, might well be worth the locksmiths' attention. Why, he asked, should a locksmith not incorporate in his lock a mechanism "so constructed that if a stranger attempt to open it it catches his hand as a trap catches a fox, though so far from maiming him for life, yet so far marketh him that if once suspected he may easily be detected"?

In fact, a locksmith did produce such a lock. He incorporated in the mechanism, close to the keyhole, a small, sharply pointed steel barb. It was so set that if anyone but the owner, who knew the secret, tampered with the lock the steel barb was ejected by a strong spring and pierced the tamperer's hand. The story goes that the locksmith himself was injured by the dart when he was demonstrating its efficiency. If so, it may have hurt him, but it would certainly have been a most convincing demonstration that the device worked!

The inventive-minded Marquis of Worcester had other suggestions to put forward:

> "A way how a little triangle screwed key, not weighing a shilling, shall be capable and strong enough to bolt and unbolt, round about a great chest, an hundred bolts, through fifty staples, two in each, with a direct contrary motion; and as many more from sides and ends; and at the self-same time shall fasten it to the place beyond a man's natural strength to take it away."

There is no record as to whether any ingenious locksmith

contrived a lock at once so light in action and so powerful in resisting unlawful entry and removal, but at least the good marquis had realized, what all locksmiths eventually came to realize, that the smaller the keyhole and key the greater the degree of security resulting—always provided that the intricacy was sufficient.

He was much concerned with escutcheons—those small, ornate plates that could be embodied in the pattern of a lock and themselves conceal the keyhole. He wanted to see a lock designed

> "with an escutcheon placed before it with this property: That the owner, even though a woman, may with her delicate hand vary the ways of causing to open the lock *ten millions* of times, beyond the knowledge of the smith that made it."

It was to be a very long time before anything approaching this happy solution to the problem of safeguarding property was arrived at; and this, as will be seen later, was the "combination" lock which is becoming more and more the standard security measure for large safes, vaults and strong rooms.

There were any number of variants to the device of shooting a steel barb into a thief's hand. For instance, many of the massive multi-bolt chests that were in common use in the Middle Ages, both in baronial halls and in churches and monasteries, were equipped with a dummy lid beneath the main lid. The thief, supposing he had been fortunate or skilled enough to master the intricacies of the lock, or strong enough to break open the top of the chest with hammer and wedge, would find immediately beneath the locking mechanism a second lid, in the form of a close-fitting tray. He would note with relief that, unlike the main lid, it did not seem to be locked in position. The fact that it had no handles for lifting would not worry him, for there, appar-

ently for his convenience, were three holes of comfortable finger size by which to lift it.

What he did not know, however—at least until bitter experience had taught him—was that the under side of this innocent-seeming tray consisted of mechanism operating on the principle of the common rat trap. Immediately he inserted his three fingers into the holes a trigger was sprung and a pair of vicious toothed jaws snapped-to on his fingers. Their grip was sufficient to hold his fingers inexorably locked beneath the tray, which in fact he could not remove. Nor could he tear his fingers out of the grip of those jagged teeth. Almost certainly the pain and shock combined would have caused him to utter an involuntary cry of agony, and this would certainly be sufficient to rouse the night-watchman or other servants sleeping around the kitchen fire. His fate was sealed. Even if his cry did not arouse the sleepers, still he was trapped. The alternatives—since the chest was too heavy to be lifted from the floor—were to chop off his own fingers and make his escape, maimed for life, or to be caught, literally "red-handed," when morning came.

The security device of the "snapping jaws" is a very old one. It is to be seen in a much grimmer form—or at least it used to be seen—in the Far East, where oriental potentates possessing enormous wealth in gold and precious stones wished to guard their valuables against theft. It was their pleasant practice to pile their valuables into a number of chests and place these on a small, artificial islet in the middle of an artificial lake in their palace grounds. They did not bother overmuch with having locks fitted to these chests, for they had a better form of protection than any lock could be. This consisted simply in letting loose a swarm of crocodiles, to swim at their own sweet will in the water surrounding the artificial islet. It was a brave and foolhardy

individual who took a chance in that water. Long before he reached the small refuge in the middle of the lake the crocodiles, which were deliberately kept on starvation rations so that they were permanently hungry, would have snapped their savage jaws and carried his still warm flesh down to their lairs beneath the surface, to be eaten when, as is their noxious habit, they found it sufficiently putrescent to be palatable.

There were variants on the steel dart and the snapping jaws that retained the element of surprise. In some locks a charge of pepper replaced the dart. The thief unwittingly touched a spring and triggered-off a charge of pepper which temporarily blinded him and almost certainly made him give an involuntary yelp of pain and surprise, sufficient to waken some light sleeper on the premises. It was, in fact, a primitive form of burglar alarm, the prototype in simplest form of the burglar alarms attached today to most premises such as banks, warehouses and blocks of offices. The basic difference is that in the prototype the burglar sounded his own "alarm," his own voice bringing about his downfall; and also the alarm was incorporated in the chest or strong-box itself. Today it is more likely to be remote-controlled, electrically operated, and automatically relayed to the nearest police station.

Not much more than a hundred years ago, when stage-coaches were still the regular form of long-distance transport both for passengers and for goods, the owners had become very worried about the increasing number of burglarious entries into stagecoach "trunks" when the vehicle was at some posting-stage and the driver and postilion were intent upon the changing of the horses. It was a parallel, in the early 1800's, of today's burglaries on our long-distance trains.

One man, who owned a fleet of stagecoaches, found an

ingenious locksmith who devised a burglar alarm that he had fitted to all his fleet. This consisted of the incorporation in the trunk-locking mechanism of a loud bell, which was automatically set in motion by a strong spring immediately the lock was tampered with by someone lacking the knowledge of how to prevent it from being rung. The result of tampering with the lock on the trunk was a prolonged and strident ringing of the bell, which had the immediate effect of bringing everyone within earshot running to the coach to find out what was amiss.

The locksmith who devised this alarm-ringing lock advertised it as follows:

> "This NOTICE LATCH has been tested on a coach from the Bolt-in-Tun, Fleet Street, London, with great satisfaction to the Proprietor."

What was never made clear, however, is whether the test was, so to speak, an official one, designed to ascertain the efficacy of the mechanism; or whether some unhappy burglar was caught red-handed tampering with the stagecoach trunk! Later, in order to safeguard the trunk and its contents even better, and above all at night when shady characters might be expected to try to do their work under the cover of darkness, a candle was incorporated in the mechanism and lit automatically by a flint spark as soon as a spring was triggered-off, thus throwing a spotlight on the malefactors, to their great discomfiture.

Even today there are still in use some old-fashioned, heavy cashboxes fitted with their own built-in burglar alarms. These consist, like the stagecoach trunks of a century ago, of a loud bell inside the box and hidden from sight. When the box is lifted—for thieves concerned with cashboxes usually prefer to pick them up and carry them away, to work on the locks at their leisure and in privacy—the bell automatically starts ringing, and it cannot be

stopped except by opening the box with the right key and disconnecting the mechanism. It has been strongly suggested that attaché-cases in which all too many firms fetch and carry their wages and takings should have them fitted with this type of burglar-alarm, so that the snatch-and-grab man may unwittingly draw attention to himself just when he least wants to do so.

The fact that burglar alarms of one sort or another had to be devised and fitted is evidence that the owners of valuables were progressively losing faith in the skill of the locksmith to devise burglar-proof locks. The locksmith seemed to have reached the end of his resources of ingenuity. He had made the wards more and more intricate; he had evolved the most extraordinary patterns for his key bits; he had designed keyholes of extravagant shapes that presented the would-be thief with a major problem before he could even insert his makeshift key; he had decorated the exterior of his locks with scrollwork of ever more fanciful designs, calculated to put the thief off the scent. But in spite of all this, even the most elaborately designed and skilfully constructed locks were succumbing to the skill of the no-less-ingeniously minded picklock.

There was a perfectly good explanation: So long as the obstacle consisted solely of wards attached to the inner face of the keyhole plate, the form of that obstacle, however complex, could be ascertained. Though it could not, of course, be seen, it could be "felt." The art of the professional lockpicker, whether he is a burglar or the expert locksmith who is sometimes called upon to pick a lock whose owner has mislaid his key, lies in his ability to "feel" the layout of the interior of a lock with such accuracy that he can make, or adapt, a new key that will operate its mechanism.

The procedure is remarkably simple. The lockpicker uses a key-blank of a size that will pass comfortably through the

keyhole. This blank resembles an ordinary key in so far as it consists of stem and bow; but the bit, instead of having been cut into some elaborate shape and so consisting of a series of steps and saw-cuts, is at present square, solid and smooth-faced. On this square bit the lockpicker spreads a thin layer of any malleable substance, such as (the long-established favorite material) wax, or alternatively putty, tallow or even soap. He then carefully inserts his key-blank through the keyhole and gives it a fraction of a turn. It cannot be more than a fraction because almost immediately the wax-smeared bit comes up against the edge of the lock wards. He presses gently, but firmly. The edge of the wards bites into the wax, cutting through it until it reaches the solid metal backing. The lockpicker then reverses its motion until the bit is vertical again, in line with the slot of the keyhole, and with infinite caution so as not to wipe off or mar the layer of wax, withdraws his key-blank.

There is now a stenciled pattern in the wax exactly corresponding to the layout of the wards. It may be a quite simple pattern of, say, two right-angled steps; or, if the lock is an expensive and intricate one, the pattern may well be a highly complex one of interlocking cuts, angles, zigzags and perforations. But it does not much matter to the expert lockpicker whether the pattern is simple or not. He can now take the key to his bench, slip it into his vise and, with a small, keenly tempered chisel, a fine-toothed saw and a wide range of key-maker's files, proceed to cut his blank to the exact pattern recorded by the wax. If he is anything of a craftsman—and the true lockpicker is usually a craftsman—the key that will result will function as efficiently in the lock, when he gets an opportunity to use it, as the original key has done.

As a matter of fact he need not follow the pattern exactly, save in one vital respect. He knows that it is in-

variably the "terminal" or "bolt" step that actually shoots the bolt; the other steps, saw-cuts and variants are merely to enable the key bit to pass over the wards. Provided, then, that he cuts his own key in such a way that there is no metal left where the wards are, and that he leaves his bolt step rigidly supported, his key will function. Most "skeleton-keys" are truly self-descriptive, for they consist of a hollowed-out key-blank with one step resembling the top bar of a "Z" or the short bar of an "L." The square or triangular spaces left by the cutting-away of the superfluous metal enables the bit to pass over the lock's wards until the bolt step engages with the bolt and shoots or withdraws it.

The professional lockpicker of course possesses a whole armory of key-blanks, of all sizes and all sections—since there are still locks with keyholes of irregular shape. He possesses also an armory of ready-cut keys, one at least of which is likely to prove capable of opening the lock in question. Most ironmongers have on sale an assortment of keys among which will almost certainly be found one that will fit any simple inner-door lock; and many have a small workshop on their premises at which a professional locksmith-lockpicker will dismantle a lock and make and fit a new key at his own bench.

The professional burglar, too, will almost certainly have his armory of key-blanks and ready-made skeleton-keys. He is as adept as the majority of locksmiths at assessing at a glance the size and approximate shape of the key required for the lock he intends to pick—though he is all too often content simply to insert a jimmy and force the lock by sheer brute strength skillfully and knowingly applied. He knows, also, something that the average purchaser of a lock all too rarely knows: that the outward appearance, especially of a cheap lock, belies its quality. The key may

appear to be most intricately cut, but there is more than a chance that in fact there are no true wards inside the lock at all, so that the pattern of the key bit is totally misleading.

There is an alternative method of "feeling" the wards of a warded lock, and it is one that a burglar of course much prefers: this is to take a wax impression, not of the wards inside a lock but of the actual key belonging to the lock. He may be lucky enough to have an opportunity to do this, and you might think therefore that the obvious thing was to keep the key for his own use. But this might not suit his purpose. For example, he might have access to the key and the lock of the strong room or strongbox at a time when he knew that there was relatively little inside that was worth stealing, whereas on a later date—perhaps when money had been paid in—it would be much more worth his attention. To keep the key just because he had access to it would be to put the owner on his guard; it could even mean that the lock would be changed.

Two outstanding burglaries effected by the use of false keys made from wax impressions most ingeniously taken will illustrate this point.

5

BULLION ROBBERIES

SOME YEARS AGO, when the normal currency was good solid gold and the vaults of the Bank of England—"The Old Lady of Threadneedle Street"—were crammed with it, consignments were frequently in transit to foreign countries: consignments very often worth many thousands of pounds even at a time when gold was worth much less than it is in today's gold markets.

One such consignment, destined for a bank in France, never got there. Instead, it was neatly channeled off into the pockets of a bunch of crooks as nimble-witted and daring as any of the thousands who have turned greedy eyes on such unlawful gain. It was before the days of air transport. Instead, the trustworthy steam train and the

equally reliable "Channel Packet," as the cross-Channel steamer was then called, provided the transport.

One of the four men concerned in a coup which netted them £12,000 in gold to share out among themselves was a goods-office clerk named George Tester. Another was a ticket printer employed by the same railway company, William Pierce. A third was a passenger-train guard, James Burgess. The fourth was named Agar, a man "Wanted" in both Australia and the United States. He had recently come to England to escape detection and, if possible, to pursue his trade in a new setting. By chance he had happened to pick up acquaintance with the three railway employees—until then quite innocent, hardworking and honest men. Burgess, for instance, had been no less than thirteen years a passenger-train guard. Agar was the leading spirit in this coup: he was the only experienced thief among the four men, and he possessed the knack of imposing his will on others; and also, as will be seen, a gift for elaborate organization.

He started work on George Tester, having been quick to discover that if gold was being consigned to the Continent it was normally carried by the South-Eastern Railway Company, which operated between London Bridge Station and the Channel port of Folkestone, whence the boats sailed for Boulogne. Tester was told to keep his eyes peeled for advance information about any particularly "interesting" consignments likely to be handled by his office. He might also, Agar suggested, run his eye quickly down the ledgers when the ledger-clerk had momentarily left his desk.

Tester agreed. And it happened that it was not long before luck came his way. His alert eye noted that the mobile safe which the railway company used for the transport of especially valuable consignments between London and the coast was being equipped with a new set of locks.

He did not need to be outstandingly intelligent to deduce that this meant it was being prepared for a consignment of unusually valuable goods—almost certainly bullion. He lost no time in reporting this development to Agar.

Agar's reaction was swift. "Get hold of the keys to the new locks for a night," he ordered. "I'll take wax impressions from them and make a set of duplicate keys, and you can return the official keys next morning."

George Tester was alarmed at the prospect but by then knew Agar well enough to realize that he was not in a position to disobey orders; Agar had contrived to achieve a hold over the three railway employees. However, he was only a clerk and, try as he might, he was unable to get his hands on those coveted keys even for a matter of minutes, let alone overnight; they were being kept safely in the pocket of a senior official of the company—further evidence of the importance attached to the anticipated consignment.

He did, however, find out something that was, from Agar's point of view, almost as useful as having temporary access to the keys, though obviously it would involve complications. He was able to report that a duplicate set of keys had been handed over to the company's representative at Folkestone, so that if the Customs officials there demanded to inspect the mobile safe he would be able to unlock it for them.

"Very well, then," Agar said, briefly. "I'll go and have a look myself at those keys. Probably they won't be as carefully guarded in Folkestone as they are in London."

He laid his plans carefully. He was after something big, and was not prepared to run the risk of anything going wrong when so much was at stake. If, as he strongly suspected, the booty was to be a valuable consignment of bullion then it was going to be worth a good deal of patient preparation.

His first step was to make up a consignment of *apparently* valuable goods and to request the South-Eastern Railway Company to have this despatched in their mobile safe, addressed to himself under an alias, to await collection at their office in Folkestone. A few days later, he traveled down to Folkestone, called in at the company's office, produced the duplicate delivery-note with his alias on it, and asked for the goods to be taken out of the safe and handed over to him.

He hoped that the clerk, when he opened the safe, might perhaps be called away for a moment or two—long enough at any rate for him to snatch at the keys and take a quick wax impression with the fold of wax with which he had provided himself. It was an act he had successfully performed more than once during his career. Luck, however, was against him. The clerk was not called away; he chatted pleasantly enough, without removing the keys from the safe, then locked the safe again and, without realizing how keenly he was being observed, replaced the keys on a hook in a corner of the office behind a grill.

Agar was actor enough to conceal his disappointment. He thanked the clerk, picked up his property and, without hurrying, left the office. He was not entirely dissatisfied: he had noted just where the safe keys were deposited when not in actual use. Meanwhile, he had a number of other things to find out about.

He spent the next twenty-four hours or so wandering apparently aimlessly in the region of Folkestone Harbour, the Customs and other offices, unobtrusively acquainting himself with the movements of shipping and, no less important, the normal routine followed before the departure of a Channel Packet, immediately following her tying-up in the dock, and before and after the arrival and departure of each boat train. Agar had a knack of assimilating details of

this kind; the knack had often stood him in good stead in the past.

He returned to London and enlisted the services of another railwayman, this time William Pierce. Together they traveled down to Folkestone, this time by a boat train well filled with passengers destined for the Continent and intended also to collect passengers who would have just arrived by the boat from Boulogne. He had observed that at this particular hour of the day the confusion caused by passengers arriving from London for embarkation on a boat that was disgorging passengers who would be wanting to board that train was very considerable indeed. This, he knew, would suit his present purpose excellently.

Arrived in Folkestone, Agar and Pierce hung about the office while incoming and outgoing passengers milled about them, demanding this, protesting against that and harassing the clerks whose duty it was to attend to them. Unobtrusively, the two men closed in on the end of the counter with the grille, behind which hung the keys. Pierce had been rehearsed in what he was to do; while Agar acted, his duty was to distract the clerks' attention with some elaborate question if, by any unlucky chance, they found themselves momentarily free from the anxious, jostling mob of questioners.

He need not, however, have worried. The clerks were almost literally run off their feet as succeeding groups of passengers clamored for their attention. He seized his moment as the expert will, timed his movements with an accuracy born of long practice. In a flash, Agar had nipped unseen behind the grille at the end of the counter, reached up, and squeezed the keys hard in a fold of prepared wax that he had in the palm of his hand. It was the work of a few seconds only. Then he was back with Pierce, swallowed up in a throng of impatient passengers. He delayed long

enough to make certain that his lightning move had not been noted by anyone, then nudged Pierce, and the two men made their way unobtrusively out of the office, joined the London-bound train and, an hour or two later, were back in their lodgings.

Without wasting time, Agar got out his tools and went to work with file and saw. The wax impression was clean-edged and clear-cut, an expert's job. And he was equally an expert at key-cutting. Indeed, Agar was something of an artist by nature. Not for him the hammer and wedge, the jimmy, the powerful wrench; still less the stick of gelignite. He preferred the artistic approach, even if it took longer to complete. His experience over half a lifetime of crime was that it had paid him good dividends. Certainly it did so in this particular case: the biggest bullion robbery in the whole long history of railways in Britain.

From this point onwards everything worked as smoothly as a well lubricated lock. George Tester was able to report in advance the day and time of the train on which the consignment of bullion was to be carried to Folkestone. It was of course a passenger train; and of course James Burgess, who had yet to play an active part in the affair, was guard on that train. William Pierce, well disguised, was aboard the train in good time. Agar himself arranged to board the train at the last possible moment. He concealed himself in a convenient spot and, the moment Burgess blew his whistle and waved his green flag, darted forward and swung himself in at the guard's doorway, which Burgess carefully but unobtrusively held open for him. If any official on the platform happened to notice, he would not necessarily be suspicious; it was not unknown for an intending passenger to cut it as fine as that.

The train's first stop was Redhill, in Surrey. There were no corridors on trains in those days, so Agar knew that

between London Bridge and Redhill he would be able to work without fear of interruption. He had a useful ally in James Burgess, who had found out from his colleague, Tester, what the weight of the bullion was to be and had collected an equivalent weight of lead shot. This he had put up in a number of strong canvas bags that would be convenient to handle and would help to deaden the sound if the chests, when the bullion had been removed from them, were clumsily handled at Folkestone and Boulogne by the company servants and those of the shipping company. The lead shot was to replace the gold bullion exactly, so that there would be no discrepancy in the weight when the tally cards were checked and compared. It was essential to their purpose that no suspicions should be aroused at least until delivery of the chests had been taken by the recipients, the French bank. By that time Agar and his confederates would have "gone to ground" in the thieves' underground world of London. It would not matter to them then that the hue and cry went up and the police went to work.

The plan operated like clockwork. Agar and Burgess, in the privacy of the guard's truck, working fast, transferred the gold bullion from the chests in the safe to a reinforced trunk that had been loaded into the truck and contained the canvas bags of lead shot. When Redhill was reached, Pierce stepped off the train, to be joined by Agar. They were, to all intents and purposes, two prosperous, well-dressed passengers. They hailed a porter and told him to collect a trunk from the guard's truck and follow them. The two men crossed to the Up platform, followed by the porter with his barrow. The Folkestone train was flagged out of the station by James Burgess. Agar and Pierce settled down to await the arrival of the next London train. When it drew in, they told the porter to put the trunk into the

guard's truck, and gave him a generous tip—they could well afford to do so!—and themselves entered, as was only right and proper for two men so well dressed and prosperous, a first-class compartment not far from the guard's van.

They were soon back at London Bridge—rather sooner than the Folkestone train reached its destination. The trunk was taken out of the truck and wheeled on a porter's barrow to a cab. Agar gave an accommodation address, and the cabbie whipped up his horse and was away. George Tester caught a glimpse of them through the window of his office as they left, and grinned to himself. It was not surprising. That evening he was to meet the others and take part in the share-out of the loot.

Agar, since he had been the "brain" behind the whole affair, not unnaturally pocketed a rather larger share of the £12,000 than the others did. Pierce, who had been his closest confederate, claimed the second largest share. James Burgess, the guard, who had actually assisted in the transfer of the bullion from the chests to the trunk, disputed this at first; and George Tester stood out for an equal share on the grounds that but for him no one would have known of the very existence of the bullion to which they had now helped themselves.

The three men quarreled, threatening reprisals. Agar grinned at them sardonically; it was not by any means the first time that this situation had arisen. Then he turned tough, threatening them that if they did not pipe down they would all be the losers. He had, he pointed out, only to drop a hint that would come to the ears of the railway company, and the three employees were for the high jump. He himself was so far unknown to the British police, and had had enough experience to know how to look after himself. The quarrel died down. After all, even if they had to accept a sliding-scale of reward substantially below that

of Agar himself, but for him, they realized, they would not have come by a single penny. They would still remain relatively poorly paid employees of a railway company.

The four men enjoyed their ill-gotten gains for two years or so. The hue and cry had of course flared up immediately the loss of the bullion was discovered on the opening of the safe in the French bank. But the police, though they followed every possible trail for months on end, and searched the hiding-places of thieves already known to them, failed entirely to trace them. Eventually they had to admit defeat.

In fact, the full story might never have come to light had not the men quarreled once more among themselves. One of them was indiscreet enough to drop a remark where it was overheard; in due course it came to the ears of the police. The four men were located and apprehended and eventually stood trial at the Central Criminal Court. Burgess, Tester and Pierce received sentences of fourteen years' transportation; Agar, whose reputation had caught up with him and who was already wanted on a number of other charges, received a sentence of transportation for life. The three ex-railway employees may well have been glad of the fact that they had been mere accessories rather than ring-leaders in the bullion robbery; if their individual shares in the loot had been smaller than that of Agar, so too had been their penalty.

In the jargon of the trade, this was an "inside" job, in spite of the fact that the ringleader, Agar, was definitely an outsider. Much more recently, however, than the bullion robbery just described there was a theft of gold amounting to many thousands of pounds which was in fact a very curious example of an inside job. This time the setting was a provincial bank and its strong room; and furthermore, the

whole operation depended on the unwitting assistance and cooperation of a member of the actual bank staff. Like the railway bullion robbery, it involved the taking of a wax impression of a vital key. It happened like this.

One day a most respectable looking elderly gentleman entered a provincial bank and announced that he wished to open an account there. He had, he said, recently returned to his native country after a lifetime spent in silver mining in South America. He had retired, and looked forward to spending his remaining years quietly in England. The bank manager welcomed this new client, especially when he noted how substantial the sum was with which he was proposing to open his account. He noted casually, too, that the address his new client gave him was in a superior residential district of the town; this was an additional guarantee of the status of the newcomer.

The elderly gentleman had time on his hands, now that he was retired. He dropped in to the bank quite frequently, to indulge in idle chat with one or other of the small staff of cashiers behind the counter, or with the manager himself if the door of his private office happened to be ajar and he did not seem too occupied. In fact, in a very short space of time he became one of the bank's best known and most welcome clients. It was not a very busy bank, and there was usually someone free and glad to chat with him for ten minutes or so.

His wife, too, occasionally met the bank manager's wife for mid-morning coffee when both were out shopping. The chief cashier's wife, too, sometimes joined them. After a time, the client casually invited the chief cashier to a meal, and little by little they came to be on visiting terms. They went to an occasional show together, or met for a drink and a smoke in one of the better hotels. The staff of the

bank was a small, close-knit community and it almost seemed sometimes as if this respectable elderly gentleman was an unofficial member of the bank staff himself.

One morning he presented himself at the bank well before opening time, a look of anxiety and urgency on his face. He was extremely sorry to be adopting such unorthodox behavior, he said, but the fact was that the morning's post had brought him a letter that required his immediate presence in London, and he would need to cash a check before he caught his train. He knew that it was strictly against bank rules and regulations, but would the chief cashier, he asked humbly, be so exceptionally kind as to oblige him for once in this regard? He really would be more grateful than he could possibly say. . . .

But of course! The chief cashier was all smiles as he welcomed him in. Anything to oblige so amiable a client. Rules? Why, he pointed out, rules were only made to be broken! The bank's outer door was closed behind him so that no one else might think of stepping inside to do business before it officially opened.

Gratefully, the elderly gentleman with the disarming manner opened his checkbook and named the sum he required. The chief cashier, however, had not yet unlocked the strong-room in which the safe was kept. Knowing—or thinking he knew—his man, he asked him if he would care to follow him and see for himself how securely his money, and the money of the bank's other clients, was kept overnight. The elderly gentleman accepted the invitation with only the slightest show of reluctance.

He may have looked elderly, but he had a keen, observant eye. In the very few minutes that it took the chief cashier to open up the strong room and the main safe behind the steel grille he had observed and noted a number of important details of routine. There had been the opening of

the main door; the switching-off of the burglar-alarm mechanism, housed in a small, unobtrusive mahogany cupboard; the opening of the steel door of the strong room; the opening of the steel grille behind that door; and finally the unlocking of the big safe in the strong room.

With effusive expressions of gratitude he collected his money and took his departure for the station, mentioning that he would be back from London within a day or two. He could not, he said, sufficiently express his thanks.

Nothing in his behavior had given the cashier, or any other member of the staff, the slightest reason to suspect that there had been anything behind this rather unusual request; if anything, they felt gratified to think that they had been able to be of service to a client whom they liked so much. And sure enough, within a very few days their respected client had reappeared at the bank. He reported that he had had a highly profitable visit to town, and as evidence of this he proceeded to pay in a substantial sum to his account. Furthermore, he explained, in order to register his very genuine gratitude for the cashier's kindness that had made possible this visit to London, he would like to invite both him and his chief assistant to dine with him in a hotel and afterwards have an evening of billiards. Two friends, he added, who were also keen on the game, would be joining them to make up a party.

The two cashiers were delighted to accept. When the evening came round they gathered at the hotel and proceeded to dine leisurely and well. After coffee and cigars they adjourned to one of the private billiards-rooms and began to play. As was the normal practice, they all divested themselves of their jackets, to play in their shirt-sleeves. They looked forward to two or three hours of play.

While they were in play, one member of the party to whom the client had introduced his two bank officials con-

trived to slip his hand inside first one then another of the pockets of two of the jackets hanging on the coat-hangers. In one of them his hand, as he had anticipated, encountered a bunch of keys. His practised fingers easily singled out the keys which would be bank keys, and it was the work of a few seconds to take impressions of these with folds of wax with which he had provided himself in advance. His absence from the table had not been noticed by the time he had replaced the keys in the pocket of the cashier's jacket, and the wax impressions in his own.

One thing, however, he had realized with regret: the particular bunch of keys certainly did not include the actual strong room key. Doubtless that key was in the chief cashier's trousers pocket. He had to do some quick thinking. A bright idea came to him. The billiards-room was somewhat hot and stuffy, he remarked, with a quick glance at his accomplices. Might it not be a good idea if, when they finished the present game, they adjourned to the Turkish Baths, which, as it happened, were in the same street as the hotel, and there spent an hour or two on a "refresher"? It was a popular manner of winding up an evening in that town. He put the suggestion forward very casually. Their host, who was not entirely surprised at the suggestion, agreed enthusiastically. They finished their game, and then the whole party adjourned to the Baths.

There, fortune played into the plotters' hands. The strong room key had been in the chief cashier's trousers pocket. When he undressed, his clothes, with those of the other men, were placed in a locker. As soon as he was well immersed, the man with the wax found an excuse to absent himself for a minute or two, slipped out to the locker room, opened the locker without difficulty and took a wax impression of the vital key. In less than two minutes he was back with the others, his temporary absence not even noticed, save by the elderly gentleman who was their host.

For quite a while there were no developments. Then, some weeks later, the respectable client called at the bank and, with many expressions of regret, announced that a business proposition too good to ignore had cropped up. It would involve him in a trip abroad that might quite possibly occupy several months, perhaps even a year. In a way it was a nuisance, he said, since he had come to England to retire and forget business altogether. However, business, he supposed, was in his blood; and anyway, this was a project that he really felt he must pursue, at any rate for the time being. He went on to say that he would be forced to withdraw the bulk of the balance that stood to his credit, since he would need a considerable sum of money in ready cash. However, he would leave a token sum in the bank, so that his account might remain open against the day when he was able to return and settle down again. He would miss, he said, the pleasant contact with his friends at the bank; but it might not be for so very long, and he certainly looked forward to renewing an acquaintanceship that had been so enjoyable—he hoped for all concerned.

The staff of the bank, from the manager downwards, said good-bye to him with genuine regret. He had been among their most friendly clients, and more than one of them had enjoyed his lavish hospitality. Those evenings of billiards, the chief cashier remarked, would be particularly remembered. When he said that, he certainly did not mean what he would have meant had he made the remark a month or so later.

For, a month or so later he arrived one morning at the bank, unlocked the main door, the door to the strong room, the door in the steel grille—but to his great surprise found it quite impossible, even with the help of his assistant, to unlock the big safe itself. Try as they would, the key simply could not be persuaded to enter the lock. Or rather, though it could with some difficulty be forced into the lock, it

could not be turned at all. It was an experience new to them both. Having tried unsuccessfully for some time, they reported to the manager. And the manager, having tried for himself and found the same difficulty, phoned the manufacturers of the safe and asked them to send one of their locksmiths with the least possible delay; until the main safe was open little business could be transacted at the bank.

The locksmith arrived, and went to work on the lock. His duplicate key failed to operate the mechanism any more than the official key would operate it. In the end he was obliged to use instruments which, though they would eventually open the safe, would inevitably damage the lock. After several hours' work he opened the safe. The manager and the chief cashier and his assistant were there to see him do it. And as soon as the big door swung back it was evident that someone had been at the safe before them. Apart from some papers and documents, it was empty. According to the chief cashier's ledger there had been almost exactly £12,000, in gold, in the safe when he had locked it at closing-time the previous afternoon.

One thing was obvious: whoever had opened the safe and removed the gold had possessed a set of keys. Not just one key; a whole set of keys. For careful examination revealed that there was no damage whatsoever to any of the bank's doors—neither to main door nor to the small mahogany cupboard door which housed the burglar-alarm. There were no scratches, no evidence that force had had to be applied. Everything pointed to its being an "inside" job.

The bank staff looked at one another. They were a small, close-knit group of men, men who had been colleagues for much of their lifetime; no, it just *could* not be an inside job!

It was the locksmith who gave them the hint as to what must have happened. The main door lock, he pointed out, functioned perfectly still; as also did the strong room lock,

the steel grille lock and the burglar-alarm cupboard lock. Only the safe lock appeared to have been damaged; and even then only to the extent that it was impossible to rotate the key within it. The keys that had been used to open these locks had all been well made, obviously by an expert; all of them, that is to say, except one, the safe key itself, which was the most elaborate of them all and therefore the most difficult to make from a wax impression. It had functioned, but imperfectly, and damaged the lock in doing so.

It was only when the cashiers heard the locksmith speak of false keys, of wax impressions, that they began to ask themselves when, if ever, anyone could have had access to the official keys. It was not a comfortable self-inquiry, because as soon as it began, various small pointers began to crowd in upon their memories. There was that unorthodox visit from the elderly client in a hurry to catch a morning train to London; there was the evening they spent with him, first playing billiards and afterwards indulging in the luxury of a prolonged Turkish Bath. Searching their memories, they recalled that they had in fact had the bank keys with them that evening. Though they knew their host, his two friends were strangers to them. The jigsaw fragments fell all too neatly into position.

They remembered something else. The client in question had withdrawn his account, save for a token sum of a few pounds, and left the country. The police were asked to make inquiries. The first thing they found out was that the forwarding address the man had left both at the bank and at the post office was a false one; in fact, it did not exist. The pleasantly spoken elderly gentleman had vanished into thin air; and many thousands of pounds, only a few hundreds of which were his own, had vanished into air no less thin. Among them, those billiards-players had cleaned out the bank, with the help of a set of false keys made from

wax impressions taken while the chief cashier and his assistant were enjoying an evening's hospitality; which meant that, though unwittingly, they were in fact playing the useful part of confederates in the burglary!

One lesson they certainly learned, those two unhappy men: not to make a habit of getting on too friendly terms with their bank's clients, certainly not to the extent of playing billiards with them, and winding up evenings in Turkish baths. Or—if the temptation to do so proved too great to resist—at least not to carry to billiards halls and Turkish baths the bank's vital keys, which are of such interest to light-fingered gentry with a knack of using folds of malleable wax.

6

THE UNPICKABLE LOCK . . .

THE EARLY locksmiths were blacksmiths, metalworkers who became specialists, for every lock was of course a handmade job. It is a curious fact that with the passage of time workers in certain industries steadily drift together, as though drawn by an invisible magnet to some focal point. Sometimes the reason is not far to seek: the ship-building industry naturally develops along the banks of great rivers and estuaries like the Tyne, Mersey and Clyde; the fishing industry develops at the seaports handiest for the known haunts of great shoals of fish; heavy engineering within easy reach of abundant coal; and so on.

It was the same with the locksmiths. This highly specialized industry, different in so many ways from other industries, found its focal point something like four centuries ago

in the small Staffordshire town of Willenhall. For four hundred years, Willenhall locksmiths have been designing and making locks and keys and selling them in ever-increasing numbers to the markets of five continents.

More than three centuries ago an observer wrote:

"The greatest excellency of the blacksmith's profession that I could hear of in the County of Stafford lyes in their making locks. They make them in Sutes [suites], six, eight or more in a Sute according as the merchant bespeaks them; whereof the Keys shall neither of them open each other's locks, yet one Master-key shall open them all: so that these locks, being set upon the doores of a house, and the inferior Keys being kept by distinct servants, though neither of them can come at the other's charge, yet the Master can come at them all.

"Nay, so skilful are they in Lock work that they can contrive a Lock so that the Master or Mistres of a family sending a servant into their closets can tell certainly by the Lock how many times that servant has been in, at any distance of time; or how many times the Lock has been shot for a whole year together: some of them being made to show it 300, 500 or 1,000 times. I was told of a very fine Lock made in this town, sold for £20, that had a set of Chimes in it that would goe at any hour the Owner should think fit. These Locks they make either in brass or iron boxes, so curiously polisht, and the Keys so finely wrought, that 'tis not reasonable to think they were ever exceeded, unless by Tubal Cain, the inspired Artificer in Brass and Iron."

Willenhall indeed was celebrated for its expert locksmiths as long ago as in the reign of Elizabeth I. Among the town's archives is a description of a lock made by a Willenhall locksmith named Mark Scaliot. It is said to have consisted of eleven pieces of iron, steel and brass, yet the whole lock,

together with its pipe-key, weighed no more than one grain of gold! Now this is obviously impossible, for a grain of gold represents 1/5760th part of a pound, Troy weight, or 1/7000th part of a pound avoirdupois, and it is inconceivable that an eleven-piece article could be made as small as that. Nevertheless, the locksmith was obviously a particularly highly skilled craftsman, and the legend of his skill has taken this rather typical form.

His legend increased. It is said of him that for a wager he constructed a "chain of gold consisting of 43 links, whereunto, having fastened to it the lock and key aforementioned, he put the chain about the neck of a flea, which drew them all with perfect ease." Perhaps it was an outsize flea!

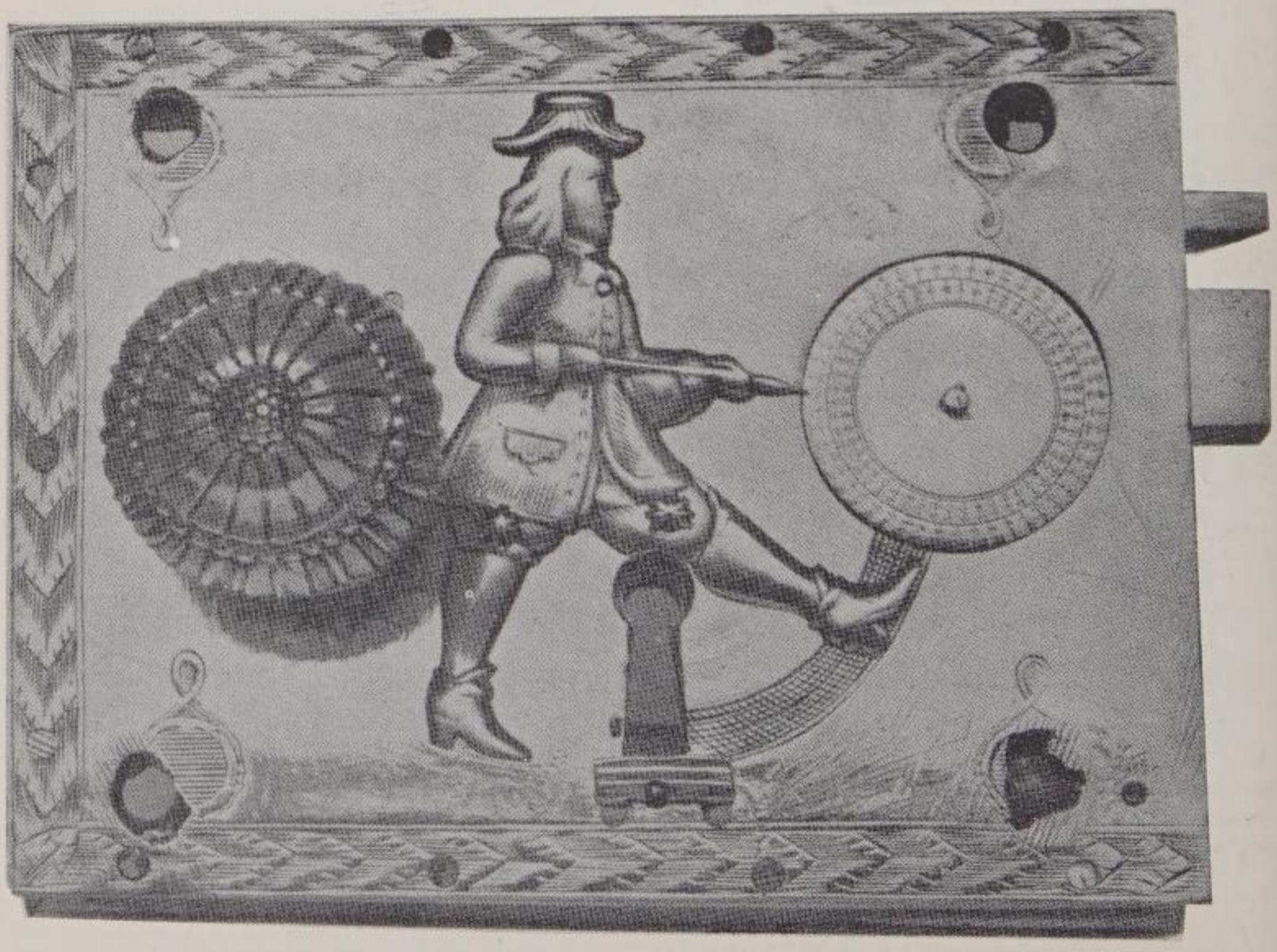
The tradition of lock-making-in-miniature has persisted down the ages. Though it is not possible to credit the stories told of Mark Scaliot, there is no reason to doubt the truth of the record of another Willenhall locksmith who, in the eighteenth century, made a lock and key which together "weighed less than a silver penny." His feat is the more remarkable that he, a man named James Lees, was sixty-five years old at the time—which, since in those days the expectation of life was much less than it is today, represents true old age. His eyesight, and the steadiness of his craftsman's hands, must have been quite exceptional even for a Willenhall locksmith.

In the middle of the next century, about the time of the Great Exhibition, a member of the famous lock-making firm of Chubb produced a patent "detector" lock so small that it was actually contained inside a gold finger ring. The ring, lock and key combined weighed no more than sixteen grains. Not to be outdone by this example of the locksmith's skill another locksmith, named Aubin, constructed a miniature four-lever padlock which was no more than 3/32nds of an inch in diameter. The advertisement which accom-

Above. A steel rim-lock with a brass case, made in London in the second half of the seventeenth century. The dial on the left indicates the number of times the lock has been opened; the right-hand one is a dummy.

Left. A French chiselled steel lock of the seventeenth century.

Below. Brass lock, probably made in Birmingham, of the late seventeenth century. The man's left leg can be drawn back to cover the keyhole, and then be released by pushing the small stud beneath it. The toe of his boot then points to a number on the dial which shows how many times the lock has been turned. The lock bolt could be released by pushing back the man's hat.



panied this lock when it was shown at the Great Exhibition in 1851 stated that it was "small enough to go inside a hemp-seed husk." Its key was barely a quarter of an inch long. Perhaps the most remarkable thing about this feat of miniature locksmithing is the fact that both lock and key were actually made by Aubin's two young sons; it is hardly surprising that they became outstanding locksmiths in their day.

It was probably a Willenhall locksmith who devised and constructed an intricate lock fixed to the door of the room in which the poet William Cowper spent much of his strange life. This was a brass lock, highly ornamented, as was usual with such locks. The chief feature of the ornamentation was a man wearing a jerkin and a Cavalier's hat and holding a firearm as a man would hold it if he were on guard against a potential enemy. To operate the lock it was necessary to locate a minute pinhole and to insert a sharply pointed stiletto. The rifleman then swung his leg forward, as though to approach the intruder, and in so doing revealed the keyhole, which had hitherto been hidden beneath his boot.

As the years went by, the whole town and neighborhood of Willenhall developed into one large "factory." It was not, of course, a factory as we understand it today. Rather, it was a collection of scattered units, all of them men occupied in one aspect or another of lock-making, but working for the most part in small, isolated groups, in ones and twos, independently of each other but by no means necessarily in competition or rivalry except in regard to the quality of their products.

Two centuries ago there were no fewer than three hundred and seventy-five locksmiths, key-makers, bolt-makers and latch-makers, almost all of whom worked on their own premises—either in a corner of the kitchen or in a shed put

The locksmith's forge in the late eighteenth century.

up in the yard behind the cottage. A considerable number of these individual locksmiths combined lock-making with some other form of livelihood. Some of them, for instance, owned small shops or taverns. The older records of Willenhall show premises advertised as "Grocer and Trunk-Lock Maker," "Hope & Anchor Tavern and Cabinet-Lock Maker," "Rim-Lock and Varnish Maker," "Registrar of Births and Key-Stamper," and "Auctioneer and Lock Smith."

A man often worked entirely on his own, while his wife looked after the shop or tavern. If he was fairly well established, however, he usually employed one or more young apprentices. Some locksmiths had as many as four boys working under them, ranging from as young as seven years old. In those days little attention was paid to the plight of young children. They were set to work to earn money for their employers, as a contemporary observer reported,

"from the earliest age at which they are able to hold a file."

One observer, more enlightened than most, was really disturbed by the conditions prevailing in the lock-making industry, the busiest in the country by far. He had noted what a high proportion of the inhabitants of Willenhall and that district were to a greater or lesser degree deformed; he had heard that citizens of neighboring towns, like Wolverhampton, referred to the Willenhall area as "Humpshire," declaring that they could recognize a Willenhall man at any distance because of his humped shoulder and his twisted manner of walking.

Because so many of them had, from a very early age, been employed at the bench for so many years, he wrote,

> "the right shoulder-blade becomes displaced and projects, and the right leg crooks and bends inwards at the knee like the letter 'K' This is the leg which is hindermost in standing at the vice. The right hand also has frequently a marked distortion. Almost everything it holds takes the position of the file. If the poor man carries a limp lettuce, or a limper mackerel, from Wolverhampton market, they are never dangled, but always held like the file. If he carry *nothing,* his right hand is in *just the same* position!"

The conditions under which these masterpieces of craftsmanship were produced certainly were bad. It was the general practice of the master locksmiths to idle during the early part of each week, recovering slowly from a misspent weekend. About mid-week they began to step up production, and by the close of the week they would often be working, this same reporter wrote, "for sixteen, eighteen or even twenty hours a day." If there was legislation about the working-hours of young boys, it was rarely enforced, for it was not easy to know what was going on in these scattered cottage "factories."

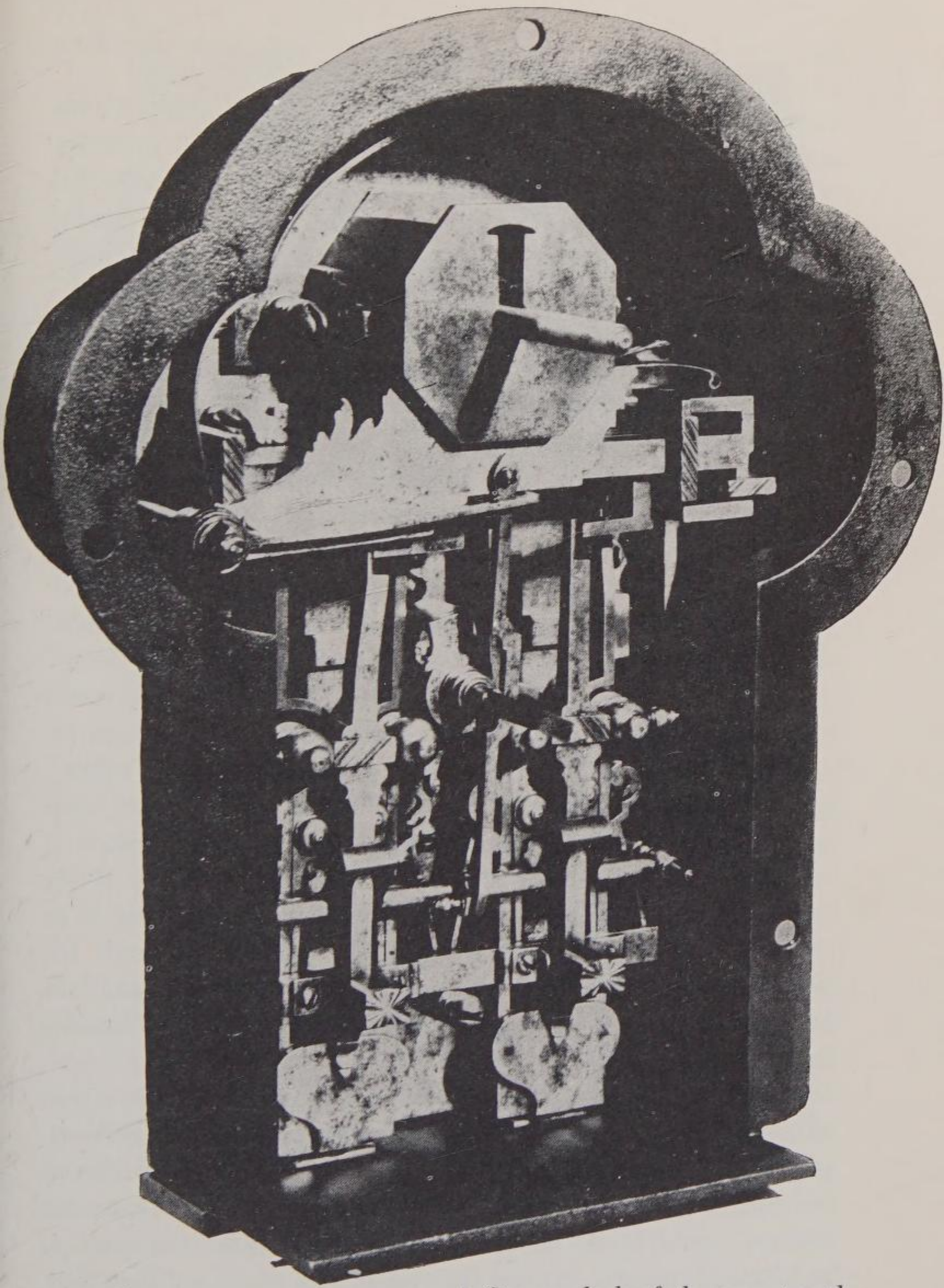
"Towards the end of the week [the report continues], when hurry and drive are the order of the day, they eat their meals while at work, and bolt their victuals standing. You see a man and his two apprentices, with a plate before each of them, heaped up with potatoes and lumps of something or other (but seldom meat), and a large slice of bread in one hand; your attention is called off for two minutes, and on turning round again you see the man and boys filing away at their vices again."

It was undoubtedly this practice of making use of cheap, unpaid labor that enabled locksmiths to turn out their products so cheaply and in such enormous quantities. It is on record that orders came in to Willenhall for 5,000 and even for 10,000 *dozen* padlocks at a time. They were sold in the plantations of South America and in India, for as little as a penny apiece!

Willenhall locksmiths were of course second to none in their ingenuity and inventiveness. They were not slow to accept the fact, unwelcome as it was, that the really skilled lockpicker could, with patience, master even the finest of their warded locks; it was necessary to devise some other lock principle that would offer greater obstacles to the thief, something that might indeed prove to be unpickable.

During the eighteenth century some ingenious brain—no one can say with absolute certainty who he was—devised the "lever" lock. It was a revolution in lock-making, a revolutionary step forward in security measures. Today, the vast majority of locks in use throughout the world are either Yale-type pin-tumbler locks or variants of the lever lock. Even the cheapest indoor lock will probably contain at least one lever; better ones will contain two or more; the really good ones will contain up to six levers and, in highly specialized cases, even more than that.

Today it is comparatively rare to come across a lock



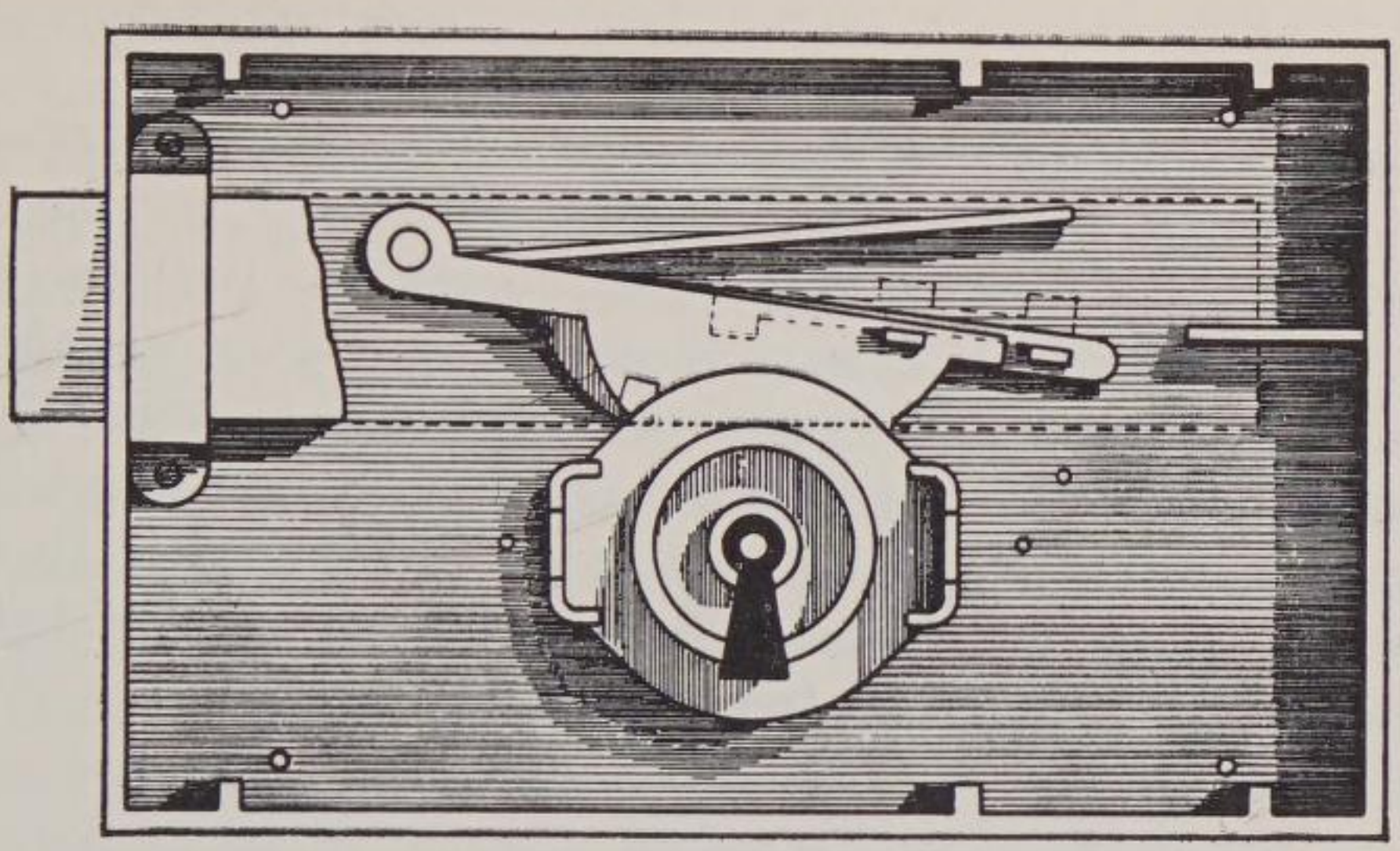
A German lock of the seventeenth century showing the increasing complexity of the mechanism. This one was probably fixed to a chest.

containing complex wards as its sole security measure. There may well be wards incorporated as an additional measure of security, but they will not be the main principle. Warded locks of any high degree of elaboration are extremely costly to produce and, as has been seen, relatively easy to pick. Agar had his ancestors, and he has his descendants too.

In order to grasp the principle of the lever lock—like all locks, a "little machine," and so well worth examining—it should be dismantled, and the inter-relationship of its working parts thoroughly understood.

Inside the lock case, the most important single feature is of course the bolt itself. This consists of the bolt "head," usually a rectangular block of iron, brass or steel which is "shot" into, and withdrawn from, the shaped recess designed for it behind the "striking-plate" on or in the door-jamb. It is part of, or rigidly attached to, the bolt "lath," or "tail," a strip of metal that slides to and fro between bearers in the lock case. In the bottom edge of the lath an arc, or an angled hollow, known generally as the "talon," has been cut out. The pressure of the bolt, or terminal, step in the key bit causes the bolt to slide to and fro when it engages with the talon. Clockwise rotation of the key slides the bolt to the right; counter-clockwise rotation slides it to the left. Because the bolt in this type of lock depends for its movement not on the pressure or tension of a spring but on the rotation of the key in both directions, it is known as a "dead" bolt.

Lying against the bolt lath will be seen one or more strips of metal, each slightly different in shape from its fellows, each pivoted at one end, and each spring-loaded so that it is under constant and steady pressure. These are the "levers" of a lever lock. In each lever there is a pair of square-cut notches, linked by a slot; it is these notches that, in fact, provide the real security of the lever lock.



Robert Barron's patent lever lock, 1778.

They are so cut as to engage with a correspondingly shaped piece of metal projecting from the bolt lath and known as the bolt "stump." When the bolt is shot, one of the notches is engaged and holds it in that position until it is released by the action of the key; when the bolt is fully withdrawn, the other notch is engaged and holds it in the alternative position until once again the rotation of the key releases it. This is a very simple form of "retainer," as the locksmith calls it, and used only in the cheaper brands of lever lock; but even in the highly complex and beautifully

machined lever locks of the most expensive class the principle remains basically the same.

For the lever-lock key has a dual function to perform: it has simultaneously to release the bolt stump from engagement in the notch, and to slide the bolt to left or right. The key bit, therefore, has to be so shaped that its bolt step will engage with the talon, and one or more of its other steps will lift the levers in such a way as to release the bolt stump so that the bolt is free to slide.

The early lever-type lock mechanism had the notches cut in the lath itself, while the stump projected from the lever. But this meant that only one lever could be incorporated in the lock, and something more complex than that was needed. The locksmith therefore transferred the stump to the lath, so that it became possible to multiply the number of levers at will, and the two notches were cut in the upper edge of the lever, or levers.

The great advantage of the lever lock over the warded type was that it was no longer possible to ascertain its mechanism by inserting a wax-coated key-blank. The vital notches were far from the keyhole, sometimes overlying one another; and until their dimensions were known, only a laborious system of trial and error enabled a lockpicker to find the key that would actuate the mechanism. Or so, at any rate, the early makers of these locks comfortably told themselves. In fact, it was not long before they were disillusioned. Lockpickers were not slow to demonstrate that they had as much ingenuity as the men who devised the locks they picked. They simply multiplied their stock of false keys, and soon found that any key with a bit not too large to pass through the keyhole but large enough to engage the talon and lift the levers would slide the bolt.

The next step, therefore, was to replace the two notches cut simply in the upper edges of the levers by slots set inside

the levers themselves. The locksmith now cut what he calls a "gate," or "gating," in the lever: a horizontal slot with two notches in it, one at each end, and cut equally out of the metal below and above the average level of the slot. The length of the gate corresponded to the length of travel of the sliding bolt; and the travel of the bolt was determined by the length of the key bit and its degree of rotation and contact with the bolt talon.

The great advantage, from the owner and the locksmith's point of view, of this gating with its inset notches was that the lockpicker now had to produce a key not merely large enough to engage with bolt and lever, but *exactly* the right size. For if the bit were not large enough, it would not lift the levers till the bolt stump had cleared the upper part of the notch; and if it were too large it would automatically lift the levers so that the bolt stump engaged with the other part of the notch. In neither case, therefore, would the bolt itself be free to slide. The lever locks incorporating this refinement were known as "double-acting" locks; they enormously increased the difficulties confronting the lockpicker, and remain a basic principle in lever locks today.

One of the best of these early experiments in double-acting lever locks was patented by a locksmith named Robert Barron in 1778. It had two levers, and the proportions of the stump and gatings were so skillfully worked out that to open the lock required a key cut to the finest limits. The lock, however, had one weakness: the lower edges of the two levers were at different levels. A lockpicker of more than average ingenuity discovered this fact and found a means of circumventing the obstacle, to Barron's great indignation.

The method the lockpicker adopted had something in common with that of the old wax-impression experts, though it called for a more delicate touch than most of them had

possessed. He first selected from his stock a key with a bit of appropriate size for Barron's keyhole. He then spread a thin line of wax, not on the face of the bit but along the edge parallel with the stem. Then, with extreme care, he inserted the key and rotated it until he felt the first hint of resistance. He immediately withdrew the key, examined the edge of the bit and proceeded to pare off a little of the metal below the point marked on the surface of the wax by its contact with the lower edge of the lower of the two levers.

He then smeared more wax on the step he had cut and inserted and rotated the key a second time. Again he withdrew it at the first hint of resistance, and again he filed away a little more metal. He performed this operation a number of times, until the time came when the resistance experienced proved to be from contact with the lower edge of the second, and higher, lever. Patiently he tested, pared away and tested his key, removing no more than the thickness of a piece of paper each time, until at length he found that the impression on his line of wax was equal all along the edge. He had thus ascertained the difference in the levels of the lower edges of the two levers. All he had then to do was to remove a microscopic film of metal from the key bit and his false key was an exact duplicate of the original one. He inserted it in the keyhole, rotated it, and the bolt step engaged with the talon while the other two steps engaged with the levers; a fraction more of a turn on the key he had made and the bolt was withdrawn, the lock successfully picked! It was to be some time before another locksmith found the solution to this particular problem.

His name was the foreign-sounding one, Bramah. Joseph Bramah was in fact a Yorkshireman by birth and a locksmith by trade. As is so often the case, the solution to the problem was an extremely simple one. It consisted of so

shaping the levers that though they had to be given varying amounts of vertical pivoted motion in order to free the bolt stump from the notches, their lower edges when they were "at rest" were uniform and in the same plane, as though they were in fact a solid piece of metal instead of being two or more separate and individual strips. This meant that if a key-blank with a waxed edge were applied to their under edges the same impression was made all along the surface of the wax and no indication given of the different range of movement in the levers. For the would-be thief this was a real poser.

Bramah's name is one of the most outstanding in the whole long history of locksmithing. And not merely because he devised this simple solution to the problem of the levers, which was adopted by succeeding locksmiths. In fact, he invented a completely revolutionary lock, unlike anything that had ever been seen before. This, the famous Bramah Lock, he patented just six years after Barron had patented his own lock.

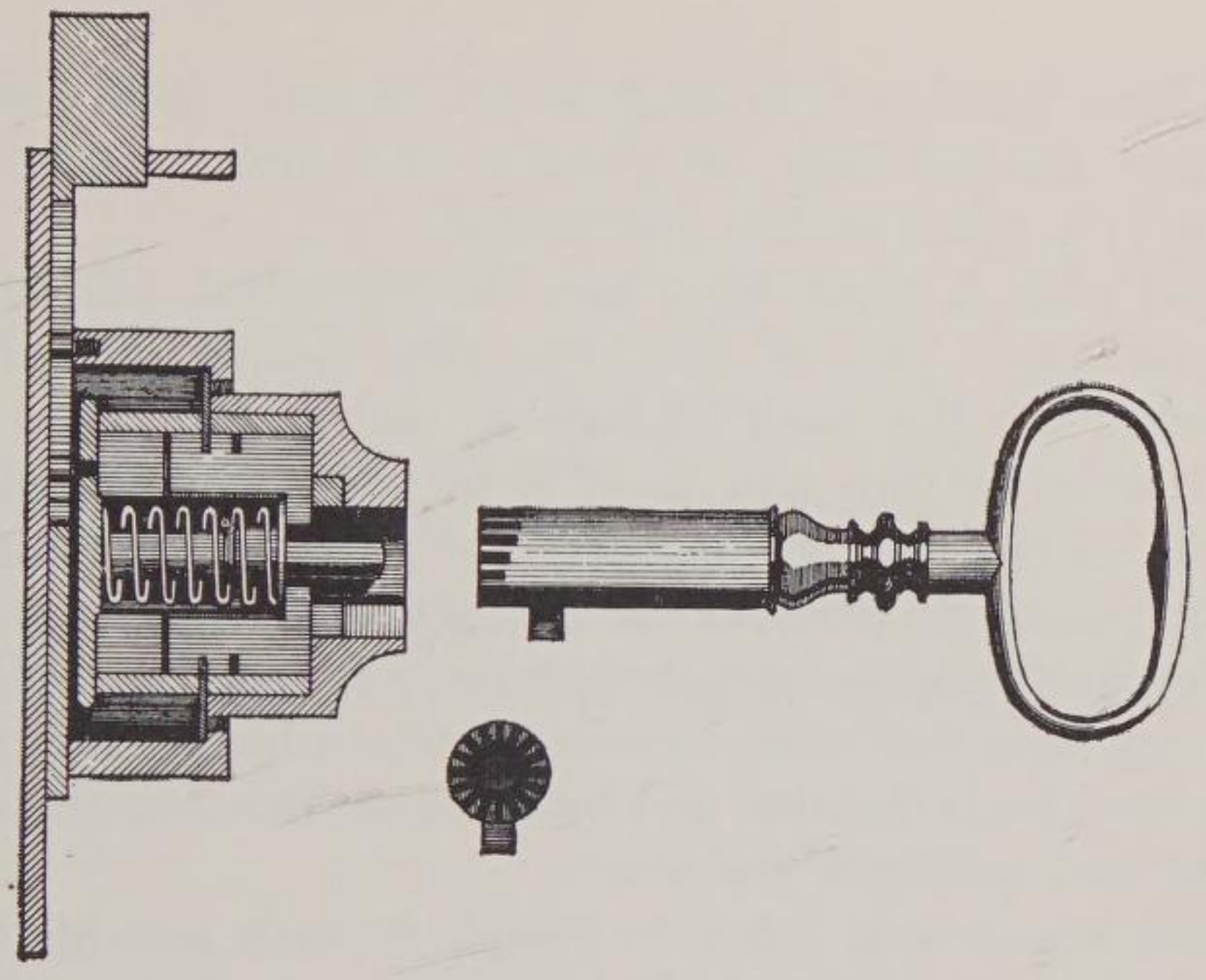
By any standards, even those of today, the Bramah Lock was a miracle of ingenuity. It combined two basic movements: the sliding (which had been used by the Egyptians, and sometimes by the Romans two thousand years later, and by various other locksmiths who had devised locks with keys that had first to be slid into position and then either moved laterally or lifted or depressed), and the rotatory, which had been the basic principle of many Roman locks and of almost all those constructed by the ingenious and painstaking locksmiths of the Middle Ages and onwards into the eighteenth century. Two fundamental principles in one lock; and the lock itself contained within a small cylinder not altogether unlike that of the Yale-type lock in universal use today!

It consisted of a compact barrel with a small, cylindrical keyhole. The key also was cylindrical, with a very small,

stubby bit and also a number of fine saw-cuts in its open, forward edge. There might be as few as five of these in the simplest version of his lock; or there might be as many as twelve or fifteen or more in his most elaborate and expensive masterpieces. Furthermore, every single saw-cut would be of a different depth from every other one. In these lay the essence of the security principle.

To open the Bramah Lock the cylindrical key had to be inserted into the keyhole against the resistance of an interior spring. Each slot engaged with the end of a "slider" concealed within the barrel and pointing outwards, though at the same time impossible to see from the keyhole. Like the slots in the key, these sliders varied in length. Each slider also had to pass through corresponding slots cut in the bolt mechanism itself; and furthermore, each slider had a fine slot cut in its edge. Only when the slot in each slider came exactly in line with the bolt could the key be rotated and the bolt be shot. For the bolt itself consisted of a number of fine slots that tallied exactly with the sliders, and all had to be synchronized before the slightest movement was possible. When it did become possible, movement was effected by the small stub on the cylindrical key engaging with a notch in the inner barrel, which itself turned within the main barrel, or cylinder, and had a projection which in turn engaged a notch in the bolt and actuated it. This was in fact an early form of remote control; it was not only revolutionary but completely effective.

If Bramah's lock had a weakness at all—and the word is not really a fair one—it was this: the lock was so complicated, the limits within which its moving parts had to be shaped so fine, that it had to be an entirely handmade job from start to finish, every successive lock an individual masterpiece. This made it an extremely costly lock to produce, for every part, however tiny, had to be made by



Joseph Bramah's lock, patented in 1784.

hand. Though a great number of these locks were in fact produced, it never became worthwhile to manufacture them in huge quantities. His principle, however, remains sound, and even today a Bramah Lock is occasionally made, by an expert locksmith, to fulfill a special order.

Naturally the "unpickable" Bramah Lock appealed strongly to those who could afford to buy them. Naturally, too, because the Bramah keys were so very much smaller than any other keys in general use in his day, they were always being mislaid. And this was a disaster, for no ordinary locksmith could pick this strange and revolutionary lock. One day, however, an advertisement appeared in the London papers. It told owners of Bramah locks who had been so unfortunate as to mislay their keys to refrain from breaking open the doors or chests to which the locks

had been fitted and, instead, to get in touch with the advertiser. Astonishingly, he guaranteed to pick any Bramah Lock with which he was confronted!

And what is more, for a time he succeeded. His system was to use a pair of very fine steel forceps, which he inserted into the small keyhole in such a way as to grip each slider in turn and press it in against the resistance of the spring until he felt its faint vibration against the locking-plate. By phenomenal delicacy of touch, and infinite patience, this remarkable lockpicker succeeded in isolating first one slider and then another, until eventually all of them had been set in position and he was able to rotate the inner barrel and withdraw the bolt.

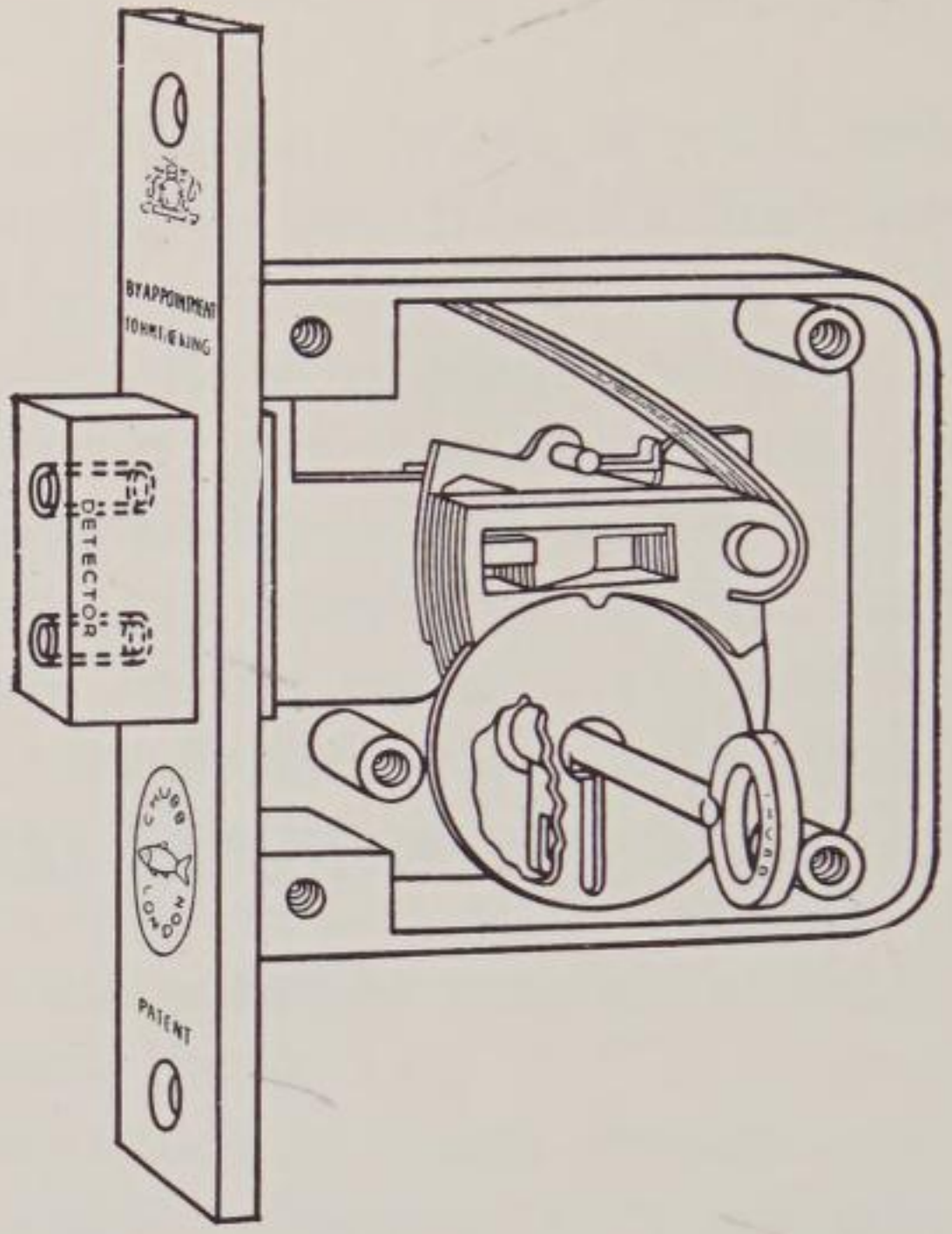
This was a rude shock to Joseph Bramah and his small team of highly skilled locksmiths; their reputation was at stake. Fortunately for them all, one of the locksmiths, a man named Russell, devised a means for counteracting this advertiser's skill. Again the solution was a simple one. It consisted simply in introducing a number of false notches into the revolving barrel in such a way as to make it immovable unless all the sliders were operated not only to exactly the right depth but at exactly the same time—as was the case when the key was used, but not when each individual slider was handled by the steel forceps. The reputation for security enjoyed by Bramah's locks soared once more, though the price inevitably increased with this new refinement. For more than half a century Bramah Locks defied the lockpicker. Nevertheless the day was to come when even the Bramah Lock was to fall victim to one of the greatest professional lockpickers who ever lived, a man who seemed to possess a magic touch that was a permanent "Open Sesame" whenever he sat down in front of a so-called unpickable lock.

7

. . . AND THE INVINCIBLE LOCKPICKER

PERHAPS, AS never before, the nineteenth century was the Age of Invention. Power-operated tools were replacing the old apprentice-turned gearing by which artisans laboriously drilled and cut and shaped. There were tools to make tools; and tools to make tools to make tools. Wealth increased, and in order to guard that wealth the demand for the products of the locksmiths increased by leaps and bounds. The cry was: Give us greater security for our new-found wealth!

Quite early in the century a locksmith named Jeremiah Chubb—founder of what is today one of the most famous lock-making and safe-making firms in the world—brought his powerful genius to bear on the problem of achieving a



Modern Chubb Detector lock. The detector spring has caught a lever which has been lifted out of position by the use of the wrong key, thus preventing the bolt from being withdrawn.

degree of security till then unknown. Though the germ of his inspiration may have been the lever lock devised by Robert Barron some thirty years before, the weakness of which he, like Joseph Bramah, had soon detected, he proceeded to devise refinements that revolutionized the early experimental lever locks.

The most important of his refinements was his famous "detector" principle. In 1818 he patented his six-lever detector lock, which was the prototype of most first-class lever locks that have been manufactured in the century and a half since his day. It was so fine a lock that it won for Jeremiah Chubb a Government prize of £100, offered for the first economically produced lock to be invented that could only be opened by its own key.

The essential feature of this new six-lever lock was a special "detector lever." This was an additional lever, so shaped and so fitted that if any one of the main levers happened to be "over-lifted"—as was usually the case when the lock was tampered with—the detector lever itself was not only lifted but thereafter remained in a lifted position. The effect of this was twofold: it enabled the owner of the lock to discover that someone had been tampering with it, and so to be on his guard; and it effectively prevented any further manipulation of the lock, by any false key or other instrument whatsoever, until the detector lever had been re-set. And this could only be done by the insertion of the key belonging to the lock.

Naturally the Government officials did not take Jeremiah Chubb's word for it that his lock was unpickable. They insisted on submitting it to the most stringent and exhaustive tests before they would part with that £100. Chubb was not in the slightest perturbed. "Do your best—or worst!" he told them with supreme confidence, and let them loose on his detector lock. The most experienced locksmiths at the disposal of the Government were called in and told to go ahead. But the lock defied all their efforts, and Jeremiah Chubb pocketed his prize.

There was an odd sequel. At that time Chubb's lockworks were in Portsmouth, and it happened that it was in Portsmouth that many convicts were then imprisoned. Among them was a man who had started life as a locksmith but had been tempted to turn to crime and had eventually been caught in the act and condemned to the hulks. He heard somehow of the Government challenge and, confident that he could do better than any of the professionals, begged the authorities to let him out to have a try at opening the new lock.

Now, Chubb heard of this, and at once saw some good

publicity for his new invention. He approached the prison authorities and persuaded them to let the convict try his luck—under the strictest police supervision, of course. Very sportingly—or perhaps with an eye to the main chance—he announced that if the man succeeded where the professionals had failed, he would hand over to him his prize of £100. No less sportingly, the Government agreed, promising the convict a free pardon if he proved to be successful!

The convict of course had everything to gain and nothing at all to lose: the prospect of not only a fat purse but unexpected freedom was a very pleasant one indeed. He was overjoyed. And one morning he was taken from the hulks and brought under strict guard to the Chubb premises, where soldiers had been organized to keep guard over him while he was at work.

If he looked confident, so also did Jeremiah Chubb, who knew well that the Government had employed the finest locksmiths in the country to test his lock. He was so confident that not only did he hand the convict a complete set of files, saws and other lock-picking tools, and a generous supply of key-blanks, but he also gave him a lock similar to the one on which he was to operate, so that he could study its mechanical principle in advance! Then he very generously—since he stood to lose not only his prize but his newly gained reputation if the convict succeeded—wished him good luck with his undertaking, and left him to it.

And what an undertaking it proved to be! Day after day for no less than ten whole weeks the convict worked, under supervision, at Chubb's lock. Over and over again the keys he had filed and cut to shape from his blanks lifted that infernal detector lever and left it "sprung," thus undoing the whole of his work up to that point. The lock had then, each time, to be removed and re-set by one of Chubb's

own locksmiths, and the convict had to start all over again.

At the end of ten exasperating weeks he gave up, admitted defeat and went back to the hulks from which he had thought he had escaped. He was honest enough to state publicly that never in his whole career as a lock-maker, or in his subsequent career as a dishonest lockpicker, had he come up against a lock so utterly impossible to pick.

Chubb of course was delighted. He had saved his £100; but what was of far greater importance, yet further convincing proof had been publicly given of the invincibility of his Detector Lock. Swollen with confidence, he proceeded to announce a further public test of his product; this time it was to demonstrate its long-lasting qualities. He had the mechanism of one of his locks coupled up to a small reciprocating-engine that had been specially geared in such a way that it would rotate a key back and forth at high speed so long as it was kept running.

This of course would be a very severe test indeed, for with every turn and reverse-turn of the reciprocating mechanism the key would be violently jerked one way or the other, and its hard-worked bit would have to engage with the levers and shoot and withdraw the bolt. In an hour or so the lock and key would have been submitted to harsher treatment than might ordinarily be given them in a long lifetime of normal use.

Again Chubb's triumph was complete. The bolt of his lock was shot and withdrawn, at high speed, no fewer than *460,000 times!* Then the engine was switched off and the mechanism and key examined minutely by experts. Apart from a high gloss on the talon, on the steps of the key bit and on the end of the pin where it rotated in the keyhole, there was no sign of wear whatsoever. When, afterwards, the lock was assembled and the key inserted in the ordinary way and turned by hand, the action was as smooth and

positive as it had been when the mechanism had first been passed by Chubb's inspector.

However, Chubb was not content to rest on his laurels. Year after year he invented some new refinement which would make his locks yet more perfect, and present even greater obstacles to the would-be thief. So excellent were the Chubb locks that when a key was lost the owner had to have the door or chest forcibly broken open, because there was no locksmith, even in the firm that had made the lock, capable of picking it!

One of the many refinements he patented was what is known as a "curtain." The keyhole was set in a small cylinder, or barrel, which rotated behind the front plate of the lock as the key itself was turned. The effect of this was to make it impossible for anyone to "feel" the movement in the interior by the insertion, say, of a piece of fine steel wire or other delicate instrument. It was a simple device and, like so many simple devices, extremely effective.

This particular invention, as a matter of fact, was the result of a minor jolt to Chubb's complacency, received when a very clever lockpicker succeeded in mastering the secret of the levers by a very ingenious process. He inserted through the keyhole a lighted taper with a very small flame, and gently "played" it on the under-side of the levers. He then inserted a skeleton key and rotated it very gently until it just made contact with the smoked under-side of the levers. Withdrawing it carefully, he noted just which parts of the edge of the bit now carried a suspicion of smoke on them. He then inserted through the keyhole a microscopic mirror on the end of a piece of flexible wire and shone a finely focused light on it. The mirror, angled like one a dentist uses to examine teeth at the back of the jaw, revealed the exact point at which the key bit had made

contact with the edge of the levers, for it had rubbed off the faint smear of smoke.

The lockpicker now had two pieces of vital information: he knew exactly where, on his false key, the levers would make contact; and he knew exactly where, on the lower edge of the levers, his key would begin the lifting action. Thereafter it was trial-and-error. But given sufficient time, and the necessary patience, he could then shape a key that would operate the levers without "springing" the detector. Time was the problem. He was lucky on this particular occasion; but Chubb's inventive genius got to work again, for he could not stomach defeat, and the "curtain" was the simple and effective result.

But the dingdong contest between lock-maker and lock-picker once begun, was to continue. The reputation Chubb achieved inevitably stimulated a spirit of challenge. In the middle part of last century the scent of challenge was continuously in the air. There was the challenge of rival locksmiths; there was the more furtive challenge of the thief; and there was even an international element in the challenges, for on the other side of the Atlantic there were locksmiths at work too—ingenious men facing the same problem as their British counterparts were facing: the perennial problem of confronting the burglar with an impregnable lock.

An American locksmith named Newell, of the firm of Day & Newell, gave the problem an enormous amount of thought. One solution he arrived at seemed a very promising one indeed. It was based on the somewhat obvious principle that the further the vital mechanism was from the keyhole, the greater would be the difficulty of operating that mechanism, save with the key designed for that specific lock. He therefore constructed what was in effect a triple-acting lever

lock: one set of levers actuated a second set, the second set actuated a third, and this in turn shot or withdrew the bolt. Pleased with his invention, he found a startling name for it, calling it The Newell Parautoptic Lock. That hideous word means, quite simply, "concealed from view."

So confident of the excellence of his new lock was he that he threw out a public challenge: To any locksmith who succeeded in opening the Parautoptic Lock the sum of five hundred dollars would be paid. He then deposited one of his locks at the premises of the State Bank, Boston, Mass., had it secured to a heavy iron chest and, under the supervision of an impartial committee appointed by the State Bank itself, had the bolt officially "shot." The key was then placed in a pouch, sealed with the bank's official seal, and handed over to a member of the committee for safe custody until it should be required.

The first aspirant locksmith turned up. He was given ten days in which to pick Newell's lock. If he succeeded by the end of that period, then the prize of five hundred dollars was his; if, on the other hand, in his attempt to open the lock he damaged its mechanism in any way, then he must agree to forfeit the sum of two hundred dollars. This of course made it something of a two-way gamble, and it was obvious that Newell was taking no chances with his lock. However, he need not have worried: neither the first candidate for prize and fame succeeded, nor did his immediate successors.

Like Chubb, on the other side of the Atlantic, Newell had complete confidence in his invention; and like Chubb he went a step or two further. He raised the value of his prize from five hundred to two thousand dollars; and as a further lure he extended the time-limit from ten days to thirty. As a further inducement, any candidate who could report some measure of success inside the first thirty days might claim

a thirty-day extension; and a further thirty days after that if he really showed that he was making progress. There is no doubt about it: Newell was supremely confident over his lock.

Why was this? The answer lies in the basic principle of his Parautoptic Lock—which went a good deal further than simply the remote-control device already referred to.

To begin with, the lock contained no fewer than twelve levers, every one of which had a different length of vertical travel. The key, therefore, had no fewer than twelve steps to its bit in addition to the vital bolt, or terminal, step. But there was a major distinction between this elaborately bitted key and other keys at first glance no less elaborate: Newell's key consisted of twelve individual teeth, or steps, each one of which could be unscrewed and replaced in a different position! The procedure was as follows: the lock was first locked with the key; then the individual components of the bit were unscrewed, 'scrambled' and replaced in a different order. The key was then handed to the candidate to try out. He had first been shown that the key, in its original form, had operated the lock; it was up to him now to find what that original arrangement of steps had been, to reconstruct the key.

Now, mathematically, if a key has, for example, *six* interchangeable bits, those bits are capable of exactly 720 different combinations—the sum-total of 6 x 5 x 4 x 3 x 2. An expert locksmith, nimble-fingered, and with a memory good enough to prevent him from repeating any one combination, working at the rate of, say, one per minute, could therefore reconstruct the key in every possible combination in twelve hours, non-stop. But the rate of increase in permutations is a steep one. Though six key-bit steps could be rearranged in all their possible combinations in twelve hours, if their number is increased to ten, then their possible combinations

run into no fewer than seven digits, and at one per minute the time necessary for their rearrangement would be no less than *ten years*!

Newell's Parautoptic Lock had not six, or even ten, levers, but a dozen. Its key therefore had twelve interchangeable steps. To rearrange all these twelve steps in the bit in such a way as to find every single permutation would, as a little calculation soon shows, involve altering one every minute, day and night, week in and week out, for—1,082 years! The locksmith would have to live for more than ten centuries, and not stop for a moment to sleep or eat, and never duplicate a single combination. It is small wonder that there is no record of Newell's lock having ever been picked, officially or otherwise. The chance of its being picked simply by the lucky lockpicker happening on the right combination at random can of course be ruled out, for the odds against this are astronomical.

The true arena for international contests in lock-picking, however, was London. And to London, in the middle of last century, came an American locksmith named A.C. Hobbs. It was not long before he brought alarm and despondency to the hearts of British locksmiths by the magic of his touch and the quite extraordinary ingenuity of his methods of attack and of the instruments he had devised to make these attacks successful.

He began very quietly. He obtained a selection of the best locks then in production—and proceeded to pick each one of them with the utmost ease. Having learned that the name of Chubb was the most notable one in the world of locks and keys, he called at his premises, chose a six-lever detector lock more or less at random, and, to everyone's consternation, proceeded to pick it just about as easily as he could have removed a winkle from its shell with a pin. This

was the latest version of the lock, until that day deemed 100 per cent secure, which neither the Government experts nor the Portsmouth convict had been able to pick.

Chubb maintained that Hobbs had merely had a stroke of quite extraordinary and unexpected good fortune; there must have been a flaw somewhere, of which he had taken advantage. Hobbs's professional pride was touched: he was not going to stand for a slur on his skill. What was more, there was an international element here—American skill versus British—and it was the year of the Great Exhibition, held in London's Crystal Palace. There was more at stake than one individual's skill.

He therefore posted a public announcement to the effect that on 22nd July, in the presence of an impartial committee of mingled British and Americans, he proposed to pick a Chubb six-lever detector lock, and to do this, moreover, within a maximum of thirty minutes! A committee of eleven men of unimpeachable integrity was appointed: men pledged to see fair play, and with no personal axes to grind. The firm of Chubb felt perfectly satisfied that the conditions were fair, and equally confident that the fluke would not be repeated.

Their confidence, however, was rudely shaken. For the firm received the following signed and sworn statement:

> "We, the undersigned, hereby certify that we attended an invitation sent to us by A. C. Hobbs, of the City of New York, to witness an attempt to open a lock throwing three bolts and having six levers, affixed to the iron door of a strong room built for the depository of valuable papers; and that we severally witnessed the operation, which Mr. Hobbs commenced at 35 minutes past 11 o'clock, a.m., and opened the lock within 25 minutes. Mr. Hobbs, having been requested to lock it again with

his instruments, accomplished this in the short space of 7 minutes, without the slightest injury to the lock or the door."

It was a shattering triumph, for Chubb had truly believed his lock to be impregnable. The firm that bore his name was startled out of its complacency. The lock mechanism was redesigned. A number of false notches were cut in the lever gatings and the shape of the bolt stump was altered so as to make it an even closer fit. Good came out of the painful shock: the famous Chubb six-lever detector became an even better article than it had been before the wizard-fingered American crossed the Atlantic and stirred up the locksmiths' world.

But Hobbs was not finished. He now turned his attention to the Bramah Lock. One of these, described by experts as "a lock of great complexity and beauty," had been on permanent exhibition in the firm's Piccadilly show window for something like forty years. Attached to it was a card stating that Messrs. Joseph Bramah offered a reward of two hundred guineas to anyone who successfully picked the lock. The announcement had been read by locksmiths for forty years, but not one of them who read it and tried his luck had ever succeeded; in fact, for many years past no one had thought it worth his while to make the attempt: it was universally believed that the Bramah Lock was inviolable.

This mere fact, of course, was sufficient to whet the ambition of A. C. Hobbs, Esquire, of New York City. He turned up one day in Piccadilly and coolly announced his intention of picking this unpickable lock. The firm of Joseph Bramah were civil, but not impressed. Once again a committee was formed to guarantee fair play; the lock was removed from the window and placed between two stout pieces of board in such a way that only the small keyhole

remained visible; the two pieces of board were firmly clamped together with stout screws, the screw-heads being sealed with an official seal, so that if Hobbs were dishonest enough to try to force the lock, his skullduggery would immediately be evident. The lock was locked and the key placed in a pouch and sealed and handed over to a member of the committee. Hobbs was offered thirty days in which to pick the lock, and no stipulation was made as to the number of hours he spent on it in each period of twenty-four.

The American locksmith thanked them politely, indicating that the thirty days would be more than sufficient for him. He made only one stipulation: that an iron strap should be fitted over the opening that led to the keyhole as soon as he had finished working on it for the day, and that the strap should be locked and sealed, as a guarantee that no one had tampered with his work during his absence.

On the agreed date, he set to work. He was permitted to come and go as he wished. Certainly he gave no hint of any sense of urgency. One day he might turn up and work on the lock for an hour or two; the next day he might not turn up at all. One day he contented himself with a mere half-hour's inspection; on another he put in a concentrated seven hours and more. In fact, he spent no more than ten days, spread out fairly evenly over the month at his disposal; and during those ten days he averaged only a few minutes over four hours a day. We know this, for he was a methodical man and kept an exact tally of the number of hours and minutes he worked on each of the ten days.

Then, after a total of just forty-four hours of work he summoned the committee to observe his next move. For this particular visit he invited also two additional persons: the managing director of Joseph Bramah Ltd., and one of his senior locksmiths. The great moment had come. Con-

cealing a grin of complacency, he quietly and effortlessly opened the inviolable Bramah Lock. And having opened it, he proceeded to close it again; and then to open it and close it again, and yet again. Just like that!

Consternation. Neither the committee nor the firm's representatives could believe their eyes. There was utter silence. Or rather, a pained silence broken only by the quiet sound of a lock mechanism being operated. The senior locksmith turned to his managing director and muttered something which caused Hobbs to prick up his ears. The managing director nodded, and turned to him. "It is evident," he said, in a voice in which he hardly succeeded in hiding his anger, "that you have managed to open our lock. But to have done so with anything but the true key makes it quite certain that you must in some way have interfered with, and therefore damaged, its delicate mechanism. Before handing over to you the prize you no doubt think you have won, I shall of course require to be convinced that this is not so."

Hobbs permitted himself a grin. "It is easy to demonstrate whether or not I have damaged your lock," he said. "Of course I know that I have not done so; but to prove this, let us have the lock opened and closed again with the key you have, I believe, in that sealed pouch."

The key was produced. The seals were broken and the screws removed so that the two boards fell apart, revealing the small, compact Bramah Lock they had enclosed. Hobbs turned to the managing director with a little bow. "Be so good as to try it in your lock yourself," he said, with just a touch of irony in his voice.

The managing director, his hand trembling slightly, inserted the key in the lock, pressed it home against the internal springs and gave it the gentle part-turn that was required to shoot the bolt. The key slid in with the ease of

the proverbial hot knife in soft butter. It turned as smoothly and surely as it had turned the day it was passed by the firm's inspector. Clearly there was not the slightest possibility that the delicate mechanism had in any way been damaged by Hobbs's manipulation. Had there been even the most microscopic damage to the edges of those sliders and the fine saw-cuts the key could never have been pressed home, let alone have actuated the bolt.

"We are unanimously of the opinion," stated the Chairman of the committee appointed to supervise this test, "that Messrs. Bramah have given Mr. Hobbs a fair opportunity of trying his skill, and that Mr. Hobbs has fairly picked or opened the lock; and we therefore award that Messrs. Bramah & Co. do now pay to Mr. Hobbs the two hundred guineas.

Signed: GEORGE RENNIE, F.R.S., Professor Cowper, of King's College, London, and Dr. Black, of Kentucky, U.S.A."

A. C. Hobbs's confidence in his own skill had been completely vindicated.

8

THE THIRD HAND AND TELL-TALE EYE

A. C. HOBBS UNDOUBTEDLY possessed the fingers of a wizard. His sense of touch far surpassed that of all the other locksmiths and lockpickers of his day. He brought to his task an individual skill which had been possessed, in smaller measure, by those who, four thousand years earlier, had attempted to pick the Egyptian pin-tumbler lock; by those who two thousand years before his time had unlawfully experimented on the Roman locks; and by those who, during the inventive centuries of the Middle Ages, had worked on those enormous, and extremely intricate multiple locks devised for the treasure-chests of barons and bishops.

But Hobbs stood in a class apart. Not for him the thin

smear of wax, clay, tallow or soap; not even the ingenious manipulation of taper-flame and wisp of smoke that could be lightly blown over hidden levers to betray their inner secrets. His methods were altogether more ingenious, more "up-to-date." So ingenious and revolutionary, in fact, that they deserve close examination.

He operated on a principle long accepted by locksmiths and lockpickers and taking this form:

> "Whenever the parts of a lock which come in contact with the key are affected by any pressure applied to the bolt, or to that portion of the lock by which the bolt is withdrawn and shot, in such a manner as to indicate the points of resistance to the withdrawal or shooting of the bolt, *such a lock can be picked*. Where a key can enter, a false key, whether in key form or in the form of bent wire, can also enter."

The firm of Chubb of course recognized this principle and accepted it, for they had no option. It was largely because of its implications that the curtain, and the barrel-and-curtain, already described had been evolved: an attempt to render impossible—or at least substantially more difficult—the task of "feeling" the interior mechanism of their locks. Hobbs of course knew about these baffling curtains. They baffled most lockpickers; but they were not going to baffle him.

To overcome this obstacle he devised a cunning instrument which was at once as delicate and yet as sure in its operation as the most deft of lockpicker's fingers; certainly it was a miracle of ingenuity. In a word, it was a "two-in-one" key, reminiscent of the elaborate and ornate medieval keys that had bits in two parts, one of which turned clockwise while the other, on a stem of its own, rotated counter-clockwise inside the outer pipe stem. But Hobbs's key was

not ornate or decorated; it was strictly utilitarian, designed for a purpose, cut with extreme accuracy, and infinitely more sensitive than those massive medieval keys.

The inner key of this dual key-instrument had only one step, the terminal, or bolt, step which engages with the talon and shoots or withdraws the bolt. At its other end, instead of the traditional key-bow in the form of a circle, ellipse, trefoil or quatrefoil, as in most keys for centuries past, it had a small, square-cut stud like the head of a small carriage-bolt, or the nut that fits a brass Meccano bolt. The key was contained within the hollow stem of a pipe-key, its bolt-step bit projecting from the pipe at one end, its square-cut stud projecting at the other end. It turned smoothly inside the pipe stem and was capable also of being slid forwards or backwards a few fractions of an inch in either direction.

The outer, and larger, key, with its hollow, cylindrical stem, also had a very simple one-stepped bit. Like the key which passed down its stem, it did not have the normal type of key-bow. But instead of having a square stud on its other end it had a small cross-handle like that of, say, a gimlet or corkscrew. This cross-handle enabled the outer key to be rotated and also slid forward or retracted on the inner key, which thus acted as a spindle.

With this dual key there was a small, quite simple looking gadget, also of course devised by Hobbs and designed to be used in conjunction with the key when he was picking a lever lock. It consisted simply of a short arm with a series of nicks cut in one edge and a square hole at one end that exactly fitted the square-cut stud on the inner portion of the key. This arm was mounted on the stud, lying out horizontally from it and of course at right angles to the key stem, with the nicks in its edge uppermost. A piece of fine thread was looped over one of the nicks and a small weight

suspended from it, hanging downwards like a miniature clock weight.

The effect of this was of course that the arm and weight, functioning as a lever, exerted a constant and steady pressure on the bolt step of the inner key, so that it was permanently in engagement with and pressing against the talon. Here, so to speak, was one of Hobbs's nimble hands permanently occupied in a vital task; yet he still had two hands left with which to manipulate the mechanism! Because the pressure was steady, any success he might have with his interior manipulation would be "recorded" by a tiny movement of the arm suspending the weight. It was a most useful additional "eye"; and a tell-tale eye at that.

To make use of this ingenious instrument of course called for exceptional deftness. But deftness was just what Hobbs possessed to a most remarkable degree. Today it would probably be said of him that he possessed "X-ray eyes"; in his day the term was unknown, but certainly those baffled experts privileged to watch him at work must have been forced to the conclusion that he possessed the gift of sight capable of penetrating behind the barrier of metal, the curtains and other forms of escutcheon, which hitherto had offered such formidable obstacles to successful lock-picking.

This gadget of his enabled him to keep a constant watch on his own progress, even though he could not actually see it. His touch was so sensitive, the movement in his lever instrument so delicate and at the same time so positive, that he could "read" his progress stage by stage as, little by little, with infinite gentleness, he slid his key in and out, rotated it, withdrew it, adjusted it, and inserted it again. While he did so he was virtually counting the hidden levers, assessing their respective degrees of resistance, their travel, the layout of the individual notches, whether true or dummy, in their gatings. And so, little by little, even the most trustworthy of

the locks revealed their hidden secrets to those magic fingers.

When he challenged the famous Bramah Lock, Hobbs had different problems to solve. He knew that it was a lock designed on a fundamentally different principle from that of the lever locks he understood so well. It was, he knew, a cylinder or barrel containing a system of finely graduated sliders, all held in position by springs set behind a locking-ring, and each differing in length from all its fellows. Each, moreover, had a fine slot cut in its edge that had to tally exactly, literally to a hair's-breadth, with the corresponding slot in the bolt mechanism. His two-in-one key, co-ordinated with his lever-and-weight gadget, would not serve his purpose here.

The very dimensions of the Bramah Lock, too, presented a considerable problem: there was practically no room, so to speak, for maneuver. Though the overall dimensions of the lock were some four inches, the actual mechanism on which he had to operate was contained within the compass of a barrel only just over two inches long and a mere inch-and-a-half in diameter. Inside the barrel of this particular Bramah Lock were no fewer than eighteen sliders—a number greater than that of the majority of locks made by this firm. So, the limits within which he would have to work were fine indeed.

Hobbs, however, seemed not in the least perturbed. Since the mechanical principle of the lock was unusual, he argued, the instrument he must design for its opening would have to be unusual too. Very well, then; he would set about it.

The instrument he devised and constructed was an exquisitely beautiful piece of minor engineering. In essence it consisted of a thin rod fashioned from highly tempered steel and armed with a set of extremely delicately cut teeth.

It was to be inserted in the tiny Bramah keyhole and then manipulated with extreme deftness in such a way that it would test, and then relieve, the tension imposed on each of the eighteen sliders in turn.

But again it was necessary, Hobbs realized, to have the use of a third hand and eye, in order to have both his own hands free for manipulation. He therefore constructed what was in effect a miniature locksmith's bench, actually mounted on the wooden block in which the lock had been sealed for protection. Its main feature consisted of a neat and efficient little clamp, fitted with a turnscrew by which he could accurately regulate the pressure on the invisible spring, moment by moment, according to changing need. It would thus be held at exactly the degree of compression or tension necessary to his subsequent move.

Hobbs also equipped himself with two long needles, again of the most finely tempered steel. One of these he used for pressing each slider in turn against the resistance of the spring; the other was shaped like a crochet needle, the hook of which, minute as it was, could be engaged in the slot and then used to withdraw any slider that had been subjected to too much pressure. As each individual slot was located and identified, its exact position was recorded with a fine-edged scriber on a wafer-thin brass strip graduated in microscopic divisions. Hobbs was not a man to leave anything to mere guesswork.

It was, of course, extremely exacting work. He was kept in a constant state of extreme alertness; he had to concentrate all his sense of touch in the tips of his fingers, feeling, and listening too, through them, and recording moment by moment the exact results of their findings. This is undoubtedly why it was his practice to work only for such short periods on any one day: there was a limit to the amount of intense concentration he could maintain as the minutes

ticked inexorably by. He knew this, of course, in advance; so it is a measure of his confidence in his own abilities that he was able to ridicule the suggestion that he might require a month in which to open the lock.

He possessed, as locksmith and lockpicker alike must always possess, infinite patience. This is revealed in his day-to-day note of hours and minutes spent at work. From time to time he made a false move, resulting in a temporary maladjustment of the mechanism and of his instruments. According to his notes, he spent something like half his time in resetting the lock so that he could start work on it all over again. Many a lockpicker, having been frustrated in this fashion, would have packed up his tools and quit, leaving the problem to someone else. Not so Mr. A. C. Hobbs, Locksmith, of New York 'City.

A considerable part of the secret of his unexpected success with the Bramah Lock lay in his use of the finely-graduated brass strip, his tell-tale eye. For on its delicate markings, its graduations so fine that it required a magnifying-glass to read the smallest of the sub-divisions, an exact record could be kept of the state of his progress up to any given moment. When he knocked off work for the day he left on his miniature bench an accurate chart, as it were, of what he had achieved to date; when he sat down to it next time, he could start off at the exact point at which he had left off. Ingenuity in the devising of lock-picking equipment; an extraordinary flair for assessing the invisible anatomy of a mechanism; patience carried to the *n*th degree; abundant self-confidence: these were the chief characteristics of this astonishing man, before whom the triumphs of British locksmiths fell like standing corn beneath the blades of a combine-harvester.

Not many locksmiths have written, or talked much, about their work; perhaps because of the very nature of their work

they tend to be rather silent, secretive, individuals. One famous locksmith of recent times, Charles Courtney, incidentally a fellow-countryman of the great A. C. Hobbs, has however written a good deal about what professional lock-picking has meant to him. Having said something about the formidable problems presented by modern locks, particularly those fitted to safes and strong-room doors, which sometimes have to be opened by a professional lock-picker on account of some emergency, he writes:*

> "To open one takes skill and knowledge, sensitive fingers, inventive ingenuity to contrive tools that will circumvent mathematics. This gives the locksmith that intoxicating feeling of using his skill to the utmost. When I confront a drill-proof safe with "dynamite" triggers and the most exacting mechanism that has been contrived, I feel a shiver of expectancy down my spine, waiting for the moment when the bolts fly back and the door opens. Whatever may be inside—and the contents are often fabulous—it is never as stirring to the imagination as the moment when the lock gives."

When Courtney wrote those words after a lifetime of work as a locksmith, making, repairing and professionally picking other makers' locks, and also collecting locks antique and modern from all parts of the world for his own private museum, he was really voicing what every true locksmith down the ages must always have felt. Whether he is an expert employed by some great lockmaking firm, or a man who has unwisely turned to crime, utilizing his skill and knowledge for unlawful ends, he must always feel a sense of elation at overcoming an obstacle thought by its designer to render the lock or safe impregnable.

*In *Unlocking Adventure*, Robert Hale Ltd.

LOCKSMITH–CROOK

PROBABLY IN no branch of industry is there to be found a higher degree of integrity among the men employed than there is in the lock-making industry. Locksmiths have a centuries-old tradition of loyalty to their calling, to the owners of the locks they construct, to the very spirit of security of which they are the agents. But inevitably there have been exceptions. And it stands to reason that if a locksmith with a high degree of skill allows himself to be tempted away from his lawful occupation, then he becomes a very dangerous individual indeed from the point of view of those to whom security is important.

Some years ago a trusted and highly experienced employee of a famous firm of safe makers, whom we will call

Thompson, was suddenly struck by a thought: what a fine position he was in for making vastly greater sums than those that appeared in his weekly pay envelope, without arousing the slightest suspicion! He was in the small group of specialists in the department which designed and made the actual keys for the safes his firm produced. What, he asked himself, was there to prevent him from secretly making a duplicate of every key he made, and saving that duplicate key "for a rainy day"?

At first he put the ignoble thought from him, as though it had stung him. His firm, he reminded himself, reposed their confidence in him, entrusted him with their secrets, relied upon the traditional loyalty of the locksmith; his conscience was uneasy. But the nagging thought persisted. Supposing, he said to himself, he lost his job, or fell foul of his employers and so wanted a means of getting even with them; supposing he wanted to launch out on his own, live better, spread himself? The answer lay right in his hand.

He succumbed to temptation. He began to slip into his overalls pocket a duplicate key to every key he made, with a tag on it giving the name, size and code-number, purchaser's name and address, of the safe for which the key had been made. He continued this practice, not merely for a few weeks or months but for a number of years. The collection of duplicate keys steadily increased. In a secret hiding-place in his house he stored the keys methodically, each bearing its tag with all relevant information on it. And in a small notebook which no one but himself ever saw he allotted a page to each key, containing details of the safe it belonged to and if, as was often the case, he had been in the party of the firm's men who had helped to install the safe, its location on the owner's premises, and other useful information.

Thompson's firm had a high reputation for the quality of its products, and they were always in demand. The locks, keys, safes, vault and strong-room doors produced were always individual jobs, no two of them alike. So, his hoard of duplicate keys multiplied as time passed by. More and more he became obsessed by them. Like a miser in olden times, when gold was the normal currency, he liked nothing better in the late evening than to open up his hiding-place, take out the keys, which now amounted to several hundred, and finger them thoughtfully, remembering the locks for which they had been cut, the massive safes which those locks were designed to seal against unauthorized entry.

In his mind's eye he saw those safes open, their valuable contents displayed before his greedy gaze. What waste it was, he heard himself saying more and more often, to possess all these keys, each one of them the means of access to wealth greater than any he had known throughout his life, and not to make use of them!

The day at last came when the temptation to launch out for himself became impossible to resist. One Friday, as he collected his paycheck, he handed in his notice. His firm was surprised, and disappointed, for he was one of its best men, one of the select few to whom the most important and responsible work was ordinarily entrusted. His skill and fine craftsmanship would be sorely missed. He was asked if he would reconsider his decision; a hint was let fall that he might expect a pay increase as from that date, and that the Christmas and other bonuses would be more considerable in future. But Thompson had made up his mind. Already he was imagining wealth far in excess of even the most generous pay raises and extra bonuses; he agreed to work out his week's notice; after that, someone else would be promoted to his specialist's bench.

He was a methodical and also an intelligent man. He had

the wit to realize that though he was a fine craftsman he could not work alone; not, at any rate, if he had set his sights on really great rewards. There might be in the big cities crooks who worked on their own, but it was the small, close-knit gangs who really did well. He was determined, now that he had burned his boats, to do well. It was to be larceny on a big scale; he had no time for minor operations.

Methodically, therefore, he set about finding a man who was an expert in taking impressions of keys. Not safe keys, of course, but the much less elaborate ones commonly fitted to outside doors. The doors of suburban and Outer London post offices, for instance; many of which might be shops as well, and so offer additional pickings. The inner keys, the safe keys, he already possessed.

In due course he found the man he wanted. No questions were asked as to his past history, or how and why he had become expert in taking wax impressions; it was sufficient that he could demonstrate his skill in this particular field. Thompson watched him take wax impressions of keys to a wide variety of locks—locks which he had obtained for the express purpose of testing out the man's competence. He was impressed by what almost amounted to sleight-of-hand as the man slipped his wax-coated key-blank into a lock and then removed it with the clear imprint of the wards cut deep into it. He was even more impressed when, having made keys from these blanks, he found that they opened the locks as smoothly and sweetly and effortlessly as the official keys did. This, he decided, was the man for him!

But surely, he thought, so skilled an operator must already be "in the business?" He put the point to him, bluntly. Yes, the man admitted that he was. Had he, then, Thompson asked him, two companions also in the business on whom he could implicitly rely? The man had. One was already a

house-breaker; the other had had a certain amount of experience of house-breaking but was best employed as an adept observer of premises. Moreover, he owned a car, was an expert driver, and had a considerable reputation for prompt, unpredictable "avoiding action."

Thompson's interest grew. Without giving too much away, he now hinted that anyone who cared to team up with him might find himself in on something very well worth while. He would like, he said, to be introduced to these two men. That was easily arranged, and the result was a heightening of his interest. He was impressed by them. They were men not over-addicted to words; men of action, rather: tough, but at the same time intelligent. They discussed various ideas, hints being lightly dropped, and as lightly taken up. At the end of the discussion it was mutually felt that the four of them might prove a very profitable association.

Thompson now turned to his notebook list of safes, and the premises in which they were installed, debating with himself as to which he would choose for a trial run. He eventually picked a post office in a general store in a south-east London suburb in which he knew that one of "his" safes was to be found. Next day he took a bus to that suburb, alighted at the end of the street and wandered leisurely down it till he came to the post office-store. He entered and bought some stamps. Then, in order to have a more leisurely look round, he asked the shop assistant for some commodity that would involve a search, and while the man was finding it and then weighing it, Thompson's quick eye moved rapidly over the premises, noting the exact situation of the safe—in a recess in a wall behind the grille at one end of the counter—and making some mental calculations. He had, as locksmiths tend to have, a photo-

graphic memory. By the time he left with his purchase he had an exact mental image of the interior of the shop, down to the smallest detail.

He knew that the weekend would be the best time to have the safe cracked. Or rather, not the actual weekend but the Friday night. For there were thousands of workers in small factories in that district who would have just been paid their week's wages and who would have promptly bought postal-orders for the weekend's football pools. By Saturday the week's takings would probably have been banked; Friday night, therefore, was the night.

Thompson did not hurry. The better part of a lifetime in the trade of lock and key making had taught him that hurry was rarely a good thing, especially when something important was at stake. He first made contact with the expert in key-impression taking, who was to be his chief accomplice. He gave him the address of the shop and told him to choose a period of fog or darkness and to obtain an impression of the outer door lock and then return with it to him, Thompson, to cut the key. In due course the blank was brought to him and he set to work to cut a key from it. He knew perfectly well that the key he cut would turn as sweetly in the lock as the shop-owner's key did.

Then he arranged to meet the other two men at an agreed rendezvous, and there he handed over the outside door key and also the safe key which he had himself cut some years before as a duplicate to the one supplied with the safe. A plan was drawn up. Two of the men were to enter the premises on Friday night, under cover of darkness, open the safe, remove all the cash it contained together with anything else of value, *lock* the safe again, leave the premises, *locking* the outer door behind them, and enter the car which would be waiting in a side street with its

engine running, ready for a swift, unobtrusive getaway. The three men were to meet him at the same rendezvous, when he would pay them for their night's work.

The operation worked exactly as planned. The two men who actually entered the premises had first studied the plan of the interior which Thompson, himself a fair draftsman, had drawn for them. They did not even need to use a flashlight. They moved swiftly, unerringly, to their objective. They wore thin gloves, and left no fingerprints behind them. It was literally a matter only of minutes between the silent insertion of the false key in the outer door and the locking of that same door behind them. The car's engine had been left on, and almost before the two cracksmen had climbed in it had slipped silently away and set off to the agreed rendezvous by a devious route. Less than half an hour later the four men were sharing out their haul.

Not unnaturally, Thompson was delighted with the smooth running of the operation; delighted, but certainly not surprised, for he was accustomed to things running smoothly. His whole working life had been devoted to the constructing of mechanisms calculated to function with the utmost precision. And not once only, but every time.

So it was to be henceforward, with this newly devised mechanism in which the human element as well as the mechanical was all-important. What had been executed flawlessly once, Thompson maintained, could be executed flawlessly every time. Provided that the maximum degree of attention was devoted to detailed planning and execution of each successive operation, there was no reason why anything should ever go wrong.

He possessed a remarkable flair for organization as well as his flair for detail. From his headquarters he planned his operations as a Chief of Staff might do in a military campaign. On his walls there were large-scale maps and town-

plans carrying an elaborate system of colored ink markings for areas that either had already been "worked" or remained still to be "worked." There were pins with colored heads to pin-point actual premises where "his" safes were located. The premises included a considerable number of suburban post offices, but also offices and premises of various manufacturers, jewelers' shops, gas and electricity companies' headquarters, and so on. From Thompson's point of view it was extremely fortunate that his old firm's products were in such universal demand.

His methodical nature stood him in good stead. He would never organize a safe-cracking in an area in which he had already carried out one of his consistently successful robberies, at least until ample time had elapsed and the hue and cry had died down. His method was to have safes opened in widely scattered areas. This entailed his recruiting more men, so that he could have gangs operating in different parts of the country either at the same time or one after another. He had no difficulty in recruiting helpers, for word went round the underworld reporting the consistent success of his coups, and stressing the generous treatment he, as organizer-in-chief, gave his accomplices.

So, one gang would perhaps have as its territory a provincial town such as Cardiff or Newcastle-upon-Tyne; another would be temporarily based in London south of the Thames; a third would operate in the northern suburbs for a time; a fourth would get busy in Birmingham, Glasgow, Liverpool or Manchester. These, and other cities and big provincial towns, were all to be found on the various maps, with colored lines drawn round and through them, their suburbs bristling with the brightly painted pin-heads.

On the whole, the gangs operated independently of one another, in some cases perhaps even unaware of each other's existence. It had been the practice in the lock-making firm

for which he had worked for so many years to keep essential raw materials, and the products deriving from their processing, in separate and as it were watertight compartments, so that one group of workmen did not necessarily overlap with another. Thompson believed that a principle which worked well in banks and strong rooms, where a vault or a safe could only be opened if two, or even three, men produced, in the right sequence and at the right time, the necessary keys, should be followed in his own particular line of business. He adopted both practice and principle, with the most satisfactory results.

The gangs worked well and loyally. They recognized that among themselves they were equals, but that they were subordinate to Thompson. He, always something of a mystery man to them, was the boss; they were his employees. Skilled in their own individual branches of burglary, they were content to leave the organization to him; he paid well, treated them well; they had confidence in him. The "fences" and "receivers" who took the goods they stole, and distributed them, had been as skillfully selected by Thompson as the men who did the actual breaking-in and stealing. It was a cosy, efficient set-up, and everyone was happy.

For ten years or so, Thompson developed and widened the scope of his illicit activities. Diligently he thumbed his way through the pages of his invaluable notebook of names and addresses and code-numbers, ticking off one by one each duplicate key as it served his purpose. He set off against each operation the value of the proceeds, and the total was mounting very nicely indeed. His weekly pay-check of ten years before was hardly even chicken-feed in comparison with what was now flowing into his various bank accounts under a variety of aliases.

To begin with he had been content with the smaller safes, even when they yielded no more than a hundred or two at

a time, or even less. But he became more ambitious as the years went by. He sent his gangs to the bigger safes, even to strong rooms and vaults. And never once did his keys fail him; never once was it necessary for his men to return later with explosives and safe-cracking equipment, to wrest by force what they had been unable to obtain by skill.

Gradually the ticks on the pages of his notebook accumulated. On one point he was adamant: he would never send a gang to open any safe a second time, no matter how sure he might be that it was well worth opening again. This was one reason for his methodical pin-pointing. And fate was kind to him—or unkind to him, if you prefer it that way. For just about the time that he was nearing the end of the safes that had still to be opened, he fell ill. Very ill. So ill, in fact, that he did not need a doctor to tell him that he had not very long to live. He knew that very well without being told.

Knowing that time was short, he sent for the most trustworthy of his deputies—that select number of men with whom he had had personal contact—to whom he had personally handed the key before each new operation and given his explicit instructions. Briefly, he told him that he was dying. Then, no doubt with real reluctance, he handed over his precious notebook, which until that moment had never been seen by anyone but himself. He handed over to him also the small number of still unused safe keys, made by him all those years ago, carefully preserved with a thin coat of vaseline against the day when they would be called into use, and bearing the tags which corresponded to the pages in his notebook, those pages which had been so meticulously written up, and which had paid such handsome dividends down the years. It is easy to imagine that he felt some emotion at that moment, as he handed over the fine specimens of his locksmith's skill, knowing that he would never see them again.

His accomplice took them, said good-bye, and left. He was a skilled man in his particular branch of their nefarious trade, but he was not, like his dying master, a born organizer. In his hands he now held the "key" to the power that Thompson had held for so many years. But he had not the wit to use the key as Thompson had done. He gathered his men together, gave them their instructions, and a few more safe-breaking operations were carried out. Nevertheless, there now seemed an element of uncertainty in each operation, and on more than one occasion it was only undeserved luck that saved a gang from disaster.

The gangs had now tasted wealth, and that wealth had begotten greed. When the last of the unused keys had been made to serve their turn, they cast about them for a new source of supply. The man they needed, now, was a man who could produce perfect duplicates of safe keys. There were not so very many such men; and of those, it was unlikely that even one would prove false to his tradition as a locksmith.

However, they did eventually find one locksmith who was prepared to play ball. They told him of the enormous wealth that could so easily be his if he did as they asked. The man at first seemed willing. But later he lost his nerve and, like one of the men in Agar's gang a hundred years before, let fall a hint of what was afoot. The Criminal Investigation Division had been for a long while seeking to trace in the pattern of safe-breaking up and down the country the gangs who were responsible. This was their chance. They moved in, and pounced. It is because they pounced, and pounced successfully, that we today know the story of a locksmith named Thompson who turned his great talents to crime instead of adhering to the code of loyalty and integrity that was traditional in his profession for centuries, and is as strong today as it has ever been.

THE ULTIMATE IN SECURITY

ALL THE locks considered so far have required keys, in one form or another, large or small, simple or complicated, for their opening. But there is one type of lock, a type that is playing an increasingly important part in life today, particularly when the maximum degree of security is essential, that has no key at all. It is the "combination" lock.

Like the Egyptian pin-tumbler lock, invented four thousand years ago and re-invented a century ago by Linus Yale, this type of lock is an extremely ancient one. Its invention was due to that painstaking, infinitely patient and extraordinarily ingenious people, the Chinese.

In remote times it took the form of a padlock consisting of an inverted "U"-shaped shackle hinged at one end into

a cylinder, or barrel, in such a way that the other end could be engaged by the interior mechanism. In order to free the shackle, a number of rings on the barrel had to be rotated until they were "set" in a certain relation to one another. It was, of course, another form of the puzzle lock, known as the "letter" or "cipher" lock. It is still widely used today in a relatively simple form as a cycle padlock.

There are usually four rings on the barrel of this type of padlock, and each ring is stamped or incised with a number of letters or other symbols, in a random order, six, eight, ten or even a dozen on each ring. Now it is obvious that the number of four-letter words that can be formed by rotating the four rings in such a way as to bring different letters into line with one another is very large indeed. It is on this fact that the owner who secures his valuables—whether a bicycle or a leather case or a steel cashbox or anything else—relies. He knows that anyone who attempts to open the padlock by arranging four sets of letters to make up just the right word will be faced with a very long and tedious task. If, instead of letters, the rings carry digits, then of course the number of possible combinations is enormously increased; the dictionary shows that there is a limit to the number of four-letter words, but four rings with, say, only eight digits on each can be arranged in more than forty thousand combinations!

The cheap letter-combination lock such as can be bought today for very little and is so handy for the quick locking of a bicycle can be fairly easily picked. It is rarely a well-engineered job, for expert machining demands great skill and a good deal of time, and these automatically force up the price of an article. To pick one of these locks it is usually necessary only to rotate first one ring, then the next, then the third and then the fourth, at the same time exerting a slight outwards pull on the shackle and listening

intently. For, as each ring comes into the designed position, its interior notch tallying with a projection on the spindle of the shackle, a very faint "give" may be detected by sensitive fingers, and an almost inaudible "click" may at the same instant confirm that movement has in fact taken place. It calls for a delicate sense of touch and a keen sense of hearing, but little more than that.

The interior mechanism that is betrayed by this slight movement and faint sound is not, in fact, very complex. Each ring, bearing the letters or digits on its periphery, has also a matching series of notches cut into its concave surface. In the rather more expensive letter locks there may also be an inner ring, capable of rotating freely but controlled by the notches inside the outer ring and itself controlling the movement of the central spindle of the shackle. The principle remains the same: Only when the right arrangement of letters or digits has been arrived at will the interior notches be in line with the projections on the spindle and allow it to be slid out of the barrel.

In spite of the fact that a greater number of combinations can be achieved by the use of digits than by the use of letters, it is letters which are generally preferred. There is an obvious reason: it is very much easier to carry in one's head the word which is the "Open Sesame" to the lock than to carry a four-digit figure. You can prove this for yourself quite easily by trying to remember, say, telephone numbers or the numbers on the license plates of cars. Unless they form some sort of a pattern they are very difficult to remember indeed. When the owner of a letter padlock has "scattered" the rings and left his property, he has only to carry a simple word in his mind; it would be quite another thing to carry a figure. And if he once forgot the figure, then he would be just as much at a disadvantage as the would-be thief.

The Chinese letter or symbol padlock was the elaborate forerunner of the simple letter lock of today; and the simple letter lock of today is the basis of the extremely efficient combination lock now so much in demand by all who have really valuable property to safeguard. If any lock can truly be deemed unpickable, then it can be most truly said of the big combination lock. It is held by experts in the trade that even the most experienced lockpicker, using the finest instruments and granted indefinite time, will be almost certain to fail in his attempt to open a modern combination lock unless he has the essential information. The only alternative remaining is to blast the safe open with explosives, drills and flame. If you follow the reports of bank robberies which seem to be taking place these days with ever increasing frequency you will find that invariably such force has been used. No burglar has the time to try to pick a combination lock by trial and error!

The modern combination lock is almost certainly an American invention—except in so far as it may be said to be merely a development of the ingenious Chinese locksmith-craftsman's work. There are various patterns, but fundamentally all consist of a single spindle with a single dial, behind which, mounted on the spindle, are either three or four wheels. This sounds simple enough; three wheels instead of even the minimum four rings of a letter lock cannot, surely, offer much of an obstacle? This is far from being the truth. In fact, a single-dial, three-wheel lock is capable of no fewer than a million changes, or "combinations"; and a single-dial, four-wheel lock is capable of no fewer than 100,000,000 combinations! The task of the would-be lockpicker is comparable with that which Newell's famous Parautoptic Lock presented; and, as with that lock, the possibility of stumbling on the correct combination is many millions to one against.

The theory involved in a combination lock is simple enough. Each number in the combination will lie somewhere between 1 and 100; in a four-wheel lock there will be four of these numbers. For example, the owner of the lock may decide to use the following four two-digit numbers: 21, 46, 37, and 94. If he is wise he will select his four two-digit groups in such a way that they bear no obvious relation to one another. That is to say he will avoid using a set of numbers such as: 20, 30, 40, 50; or: 12, 24, 48, 96. For in each of those cases there is a clear-cut relationship between the figures: they ascend in tens, or each doubles the one before it. It will be seen later why it is unwise to select groups of numbers that can be related to one another.

In order to operate a combination lock the knob on the outer end of the spindle (the only part of the whole lock, except for the outer dial, that can be seen on the door) must be turned to the right until the number first selected for the combination reaches for the *fourth* time the setting mark on the dial. The knob must then be rotated in the opposite direction until the second selected number comes into position on the setting mark for the *third* time. The direction of rotation is then reversed again, the knob being turned until the third selected number reaches the setting mark for the *second* time; and so forth.

This may seem an extremely laborious method of operating a lock, but in fact it is very quickly performed by the man who has become accustomed to it. These apparently complicated alternating reversals of rotation are necessary to operate the invisible wheels that constitute the interior combinations and actuate the vital locking and unlocking mechanism. For eventually all the wheels, or disks, will have been brought into a position in which the individual cuts or notches in their peripheries are in alignment. This is the same principle as the lining-up of the notches inside the

four rings of the letter lock, but of course there are many more notch positions, and they are also very much more finely graduated and machined.

When the notches are once aligned, the knob is rotated once more. This action causes an inner arm, or lever, to fall or rise; and this in turn actuates the bolt mechanism, freeing the bolts and permitting them to slide. The door is then capable of being swung open.

Though the unlocking of the safe or strong room door demands a routine of ordered rotatory motions, it is the work of only a moment to close and lock it. The door is pushed to, and one single turn of the knob is sufficient to shoot the bolts and simultaneously wedge the locking arm, which can only be freed by the complex movements of the inner wheels with their elaborate sequence of grouped digits. The instant the door is closed and the bolts shot, a single spin of the knob each way "scatters" the combination and so renders the lock impregnable.

The modern combination lock has a further merit. The sets of digits can be varied at will—if the owner wishes, every time the safe is opened and closed, though it is unlikely that he will think this necessary. All he has to do is to insert a special "change" key. Turning this temporarily unlocks the inner rings from the outer parts of the wheels. The relationship between these is then revised, a new set of combinations imposed upon them, and the disks thus entirely reset. The change key is then used to lock the inner and outer parts of the disks into one, and then withdrawn. From that moment onwards the lock will only respond to the operation of the dials according to the new combination. The adjustment, of course, can only be carried out while the safe door is open.

Obviously there is little point in varying the combinations. It is only done if the owner has reason to suspect that

someone has come into unlawful knowledge of the current combination. In the same way many homeowners have a new lock fitted to their front doors if they are unfortunate enough to lose the key, knowing that if the key is in someone else's possession they cannot be certain that there will not be unlawful entry some dark night. To keep on changing the combination would be to run the risk of forgetting, or confusing, the sets of figures.

It is a common practice among banks and similar institutions responsible for large sums of money to place the combination numbers in a sealed envelope and deposit this in the strong room of some other bank. Then if, for example, the chief cashier is taken ill, or has a lapse of memory, the combination necessary for the opening of the safe or strong-room can be obtained from the sealed envelope. In a town with a number of banks it may well be that each bank possesses the sealed envelopes of each of the other banks in the district.

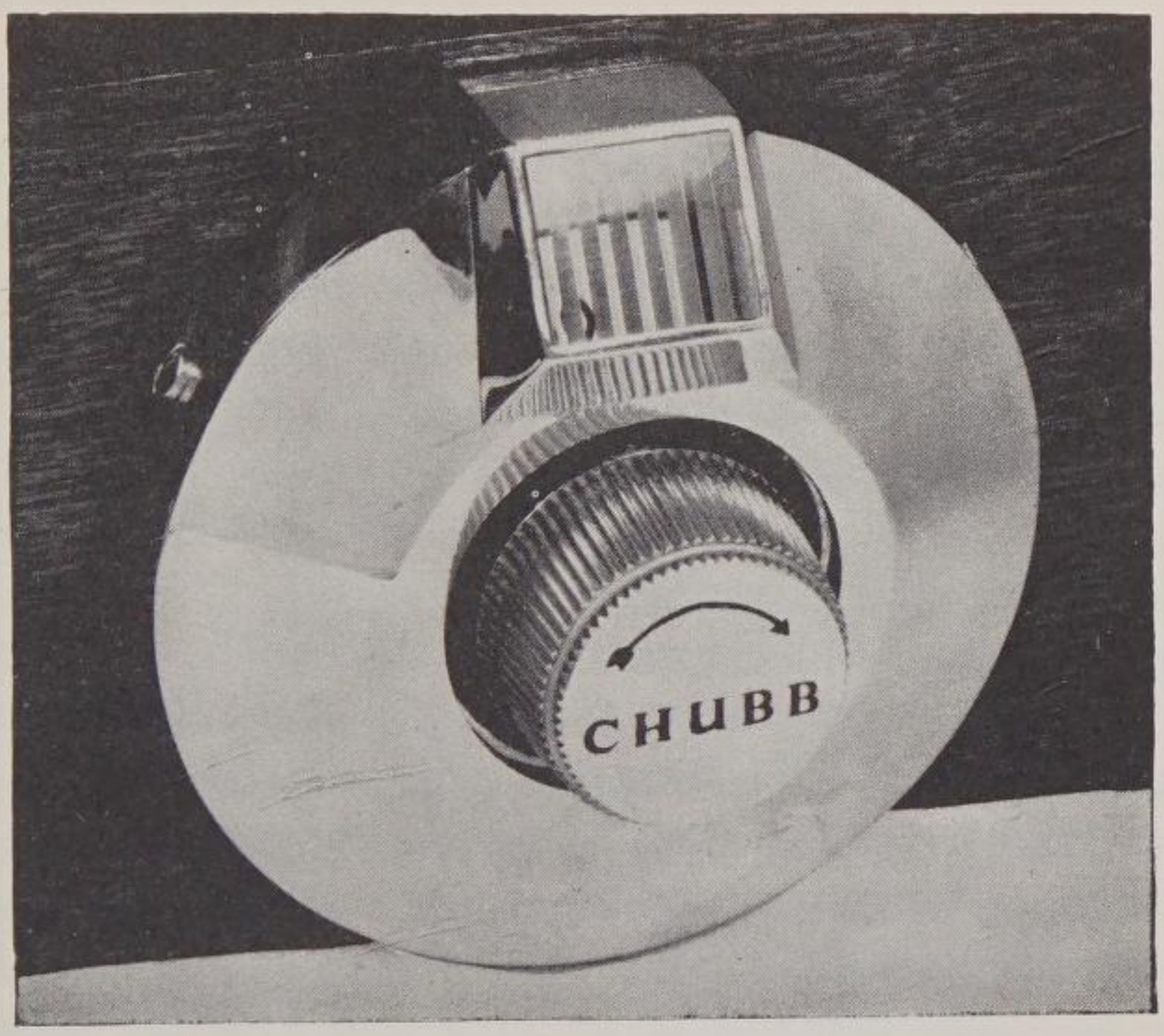
It has been said, and it is almost certainly true, that it is impossible to pick a modern combination lock. Nevertheless, by dint of applying skill and know-how, and also—strange as it may seem—a knowledge of the way another person's mind works, sometimes the "impossible" can be performed. An expert locksmith-lockpicker, if he is taken into the confidence of the banker or other official whose combination lock has been rendered unopenable because the necessary figures have been lost, has been known to open the lock by what seems on the face of it to be nothing short of magic. His secret lay in an intuitive flair for understanding the thought processes of the man who was responsible for setting the combination! A parallel to this is the skill with which some practised crossword-puzzle solvers achieve their results: they have already solved so many crosswords that have been set by the same puzzle-setter that they have

come to recognize "how his mind works." They instinctively know, that is to say, the sort of word that interests him and what lies behind those deceptively worded "clues." So with the professional lockpicker.

Imagine the situation. The chief cashier, or whoever it is that is responsible for setting the combination and each morning opening up the strong room by operating it, has died overnight, or had a stroke, or temporarily lost his memory. No one else knows the combination. The bank must be open to its clients; their checks must be cashed. The only solution is to call in a professional lockpicker, an employee of the firm that constructed and installed the strong-room door and lock.

He knows, of course, of the millions-to-one odds against his finding the combination by chance. But he knows also two other things. One is that, to the highly trained ear and touch, delicate manipulation of knob and dial will sometimes reveal the merest suspicion of movement that will enable the lockpicker to come near at any rate to the first of the three or four combinations he has to find. The other is that it is not unusual for a chief cashier to keep somewhere among his papers, not a duplicate of the whole combination but a block of digits from which he has extracted the combination then in use.

For example, on this sheet of paper in a safe drawer of his private desk there may well be a square of digits bearing no obvious relationship to one another whatsoever: four, five or six rows, perhaps, each containing six or eight digits. From this block he will have taken his four pairs. He may have selected his pairs as follows: the first pair from the top row; the second pair from the second row, beginning immediately after the pair above; the third pair from the third row, beginning immediately after the second pair; and the fourth pair in the fourth row, beginning immediately



Keyless combination lock dial fitted with a shield which restricts the view of the numbers to the operator only. The arrow indicates the direction of the first series of turns.

after the third pair. Or his pairs may have been "stepped" diagonally downwards from left to right. Or diagonally upwards from left to right. Or first to the right, then to the left. But almost certainly, though there will be no relationship between the actual digits, there will be some sort of a pattern to them, even though it may be only a half-conscious one. And in any case the pairs of digits will all come from within the framework of the block, or square.

The lockpicker begins to ask questions. Was the chief cashier a methodical sort of a man? Was he, so to speak, imaginative? What was the date of his birthday, by the way? What was the date on which he probably last "set" the combination? Had he, as so many people have, a "favor-

ite" or "lucky" number? And so on. The questions may seem irrelevant, absurd; but they are not necessarily so.

For example, if the chief cashier is known to be an extremely methodical man—even to the point of fussiness—it is very possible that the pattern of numbers extracted from the block will be a very rigid one. Again, if the date of his birthday happened to be represented by any one pair of digits in the block it is quite possible that he has used this as a starting point. And so on.

The professional lockpicker counts himself very fortunate if he is handed one of these digit blocks, for at once the number of possible combinations is substantially reduced. With his inborn skill and delicacy of touch, his ability to carry figures in his head and ring the changes on them, his accumulated knowledge of the way people's minds work, his fundamental knowledge of the invisible mechanisms of individual types of lock, and with the patience and persistence that he has developed over a lifetime in his trade, there is more than a slight chance that he will succeed in his task.

His services are well worth the fee that his firm will charge for them. For the only alternative, as the banker well knows, is to force the lock. And this is not only a costly performance in itself but will involve the even more costly replacement of the mechanism, perhaps even of the safe or strong-room door in its entirety. Simpler by far, he will say to himself when this catastrophe has befallen him, to have deposited in some other bank in the town either a duplicate set of keys or, in the case of the combination lock, a sealed envelope with those vital figures clearly set out, for use in just such an emergency.

There is not much point in fitting a combination lock—inevitably an expensive item—to a small safe. Well aware that it is next to impossible to pick such a lock, the safe-

breaker simply arranges to pick up the safe and carry it to some hiding-place where he can work on it at his leisure, using tools and explosives if necessary. Rather, it is the big safe, the vault or strong room, that is secured with the combination lock. And in order to justify its initial expense the strong room must be so designed that even its exterior presents the bank robber with the maximum degree of difficulty.

The basis of all this is, essentially, solidity; solidity allied, so far as is practicable, with inaccessibility. Designers and constructors of strong rooms more than a century ago recognized this principle; it was based on the principle of those medieval owners of property who concealed their valuables behind enormously thick stone walls and protected the walls themselves with a wide and deep moat. Moats are a little out-of-date nowadays, but there are other methods of rendering strong rooms difficult to get to as well as almost impossible to penetrate.

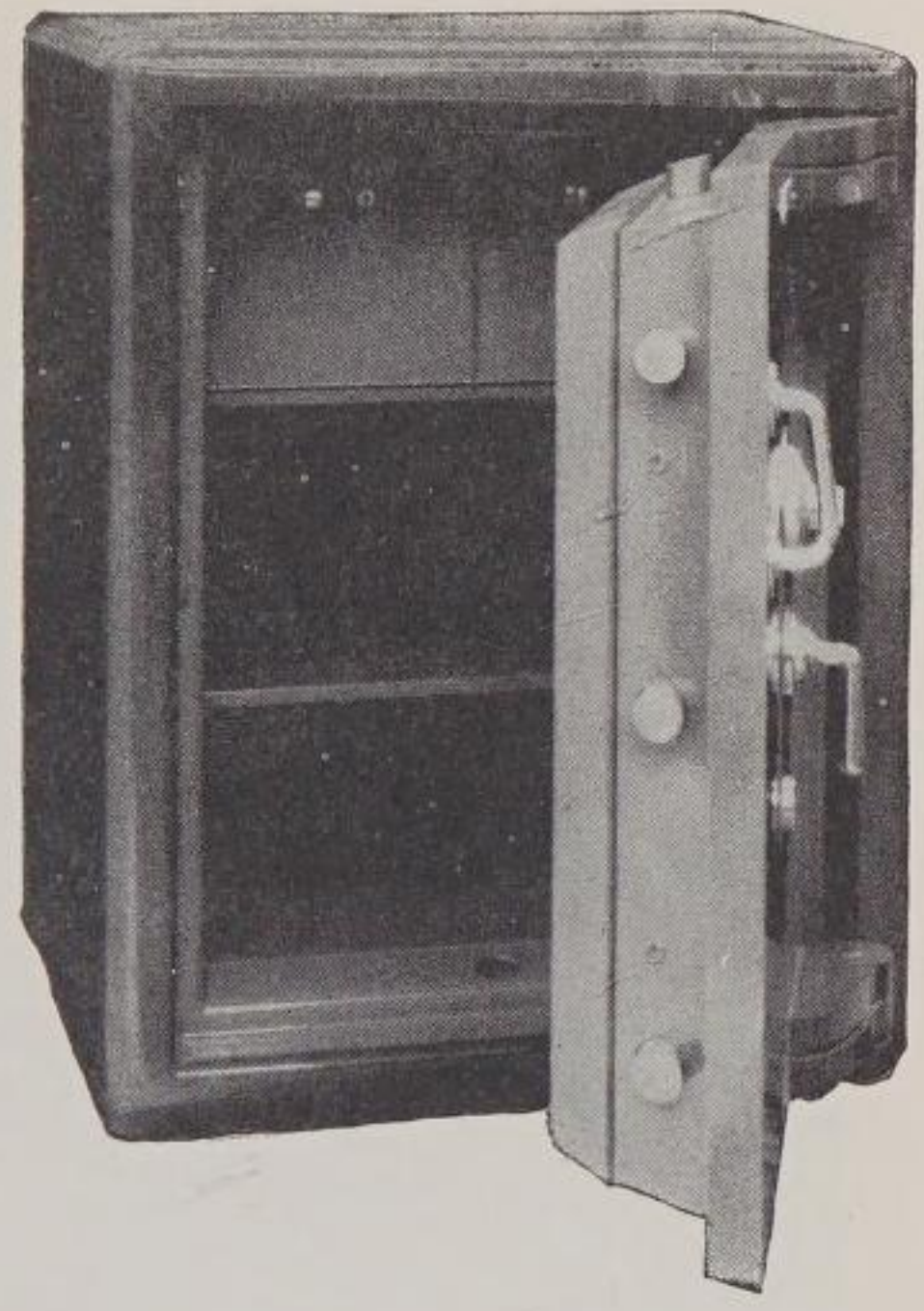
The constructor of one nineteenth-century strong room, for instance, had it mounted on a massive iron column which, like the garage lift of today, could be raised and lowered hydraulically. At the end of the bank's working-day the whole steel-bound strong room could be lowered thus through a cavity in the floor until it had passed out of sight. The floor surrounding the cavity into which the strong room had been lowered was fitted with heavy glass panels, through which the watchman could check whether any burrowing was going on below ground level.

It has, however, been found that experienced cracksmen can cut their way through solid brick, stone and concrete in an astonishingly short space of time, with the tools and equipment available to them today. Much thought and ingenuity, therefore, have been devoted by designers and constructors of safe-deposits and strong rooms. Whenever

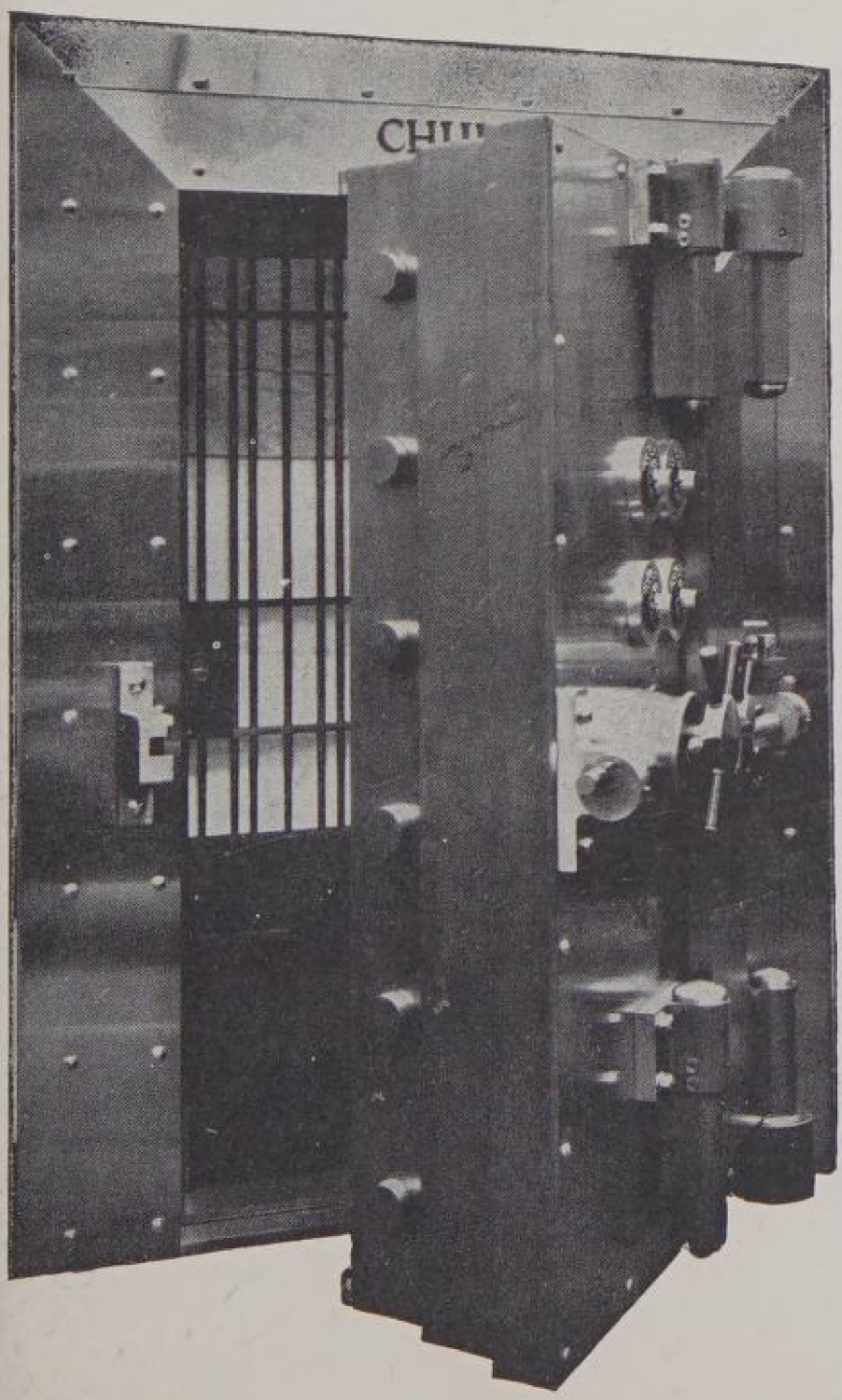
possible the strong room is actually built below ground level. In the United States it is more usually known as a "vault," perhaps because a vault is ordinarily carved out underground. If it is practicable, then the vault is cut out of the solid bedrock on which the foundations of the bank themselves are laid.

But it is not simply a cubic cavity cut out of bedrock; rather, it consists of massive, multi-ply walls. There will be an outside wall of concrete, usually if not always reinforced with steel bars. Behind this outer wall there will be a second "ply," or layer, consisting of what is called open-hearth steel; behind this there will be alternating plies of chrome steel and open-hearth steel with, interspersed between them, layers of flame-cutter-resistant material. Behind all this there will be an elaborate framework of steel girders, often in "H"-section, interlocked and embedded in more concrete in such a way that if the bank robber has in fact managed to cut his way through all the steel and concrete up to that point he then finds himself confronted by an obstacle so designed that it will involve an immense amount of time to cut a hole through it large enough to climb through with his safe-breaking equipment.

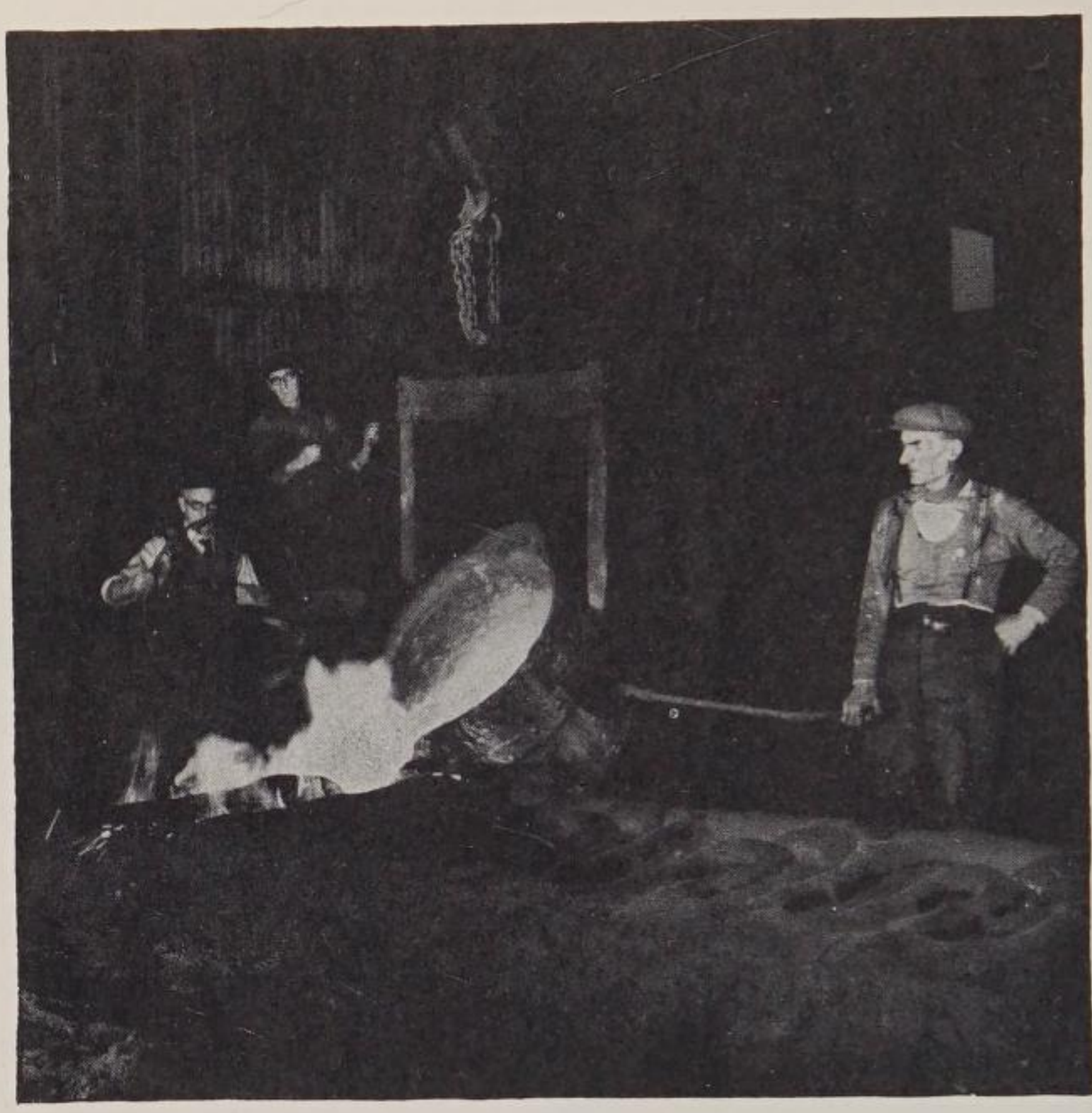
Further, the whole steel-and-concrete mass of the strong-room may be built on great piles in such a way that not only its four walls and roof can be kept under observation but it will also be impossible to tunnel through the bedrock and come up beneath the floor without being detected. An elaborate system of slanted and angled mirrors, in conjunction with concealed lighting, will enable the night-watchman to keep an eye on the whole of the exterior of the strong room from one point of vantage, without being obliged to move about and so risk proclaiming his presence to the intruder. And there will of course be a passage right round the strong room along which he can parade and carry out his routine inspections.



A safe giving a high degree of resistance to the methods of the modern would-be robber, including the use of explosives. It has a keyless combination lock and a key-operated lock, giving dual control.



A strong-room door fitted with four keyless combination locks each capable of a hundred million different combinations. The door weighs about twenty-five tons.



Twentieth-century security: filling a strong room door with anti-blowpipe alloy.

Like the walls, and for much the same reason, it is the normal practice to fit extremely thick doors to a strong room. They may be as much as two feet or a yard and more. There is a very good reason for this. It is not merely that a thick door is naturally stronger than a thin one, that a solid mass of steel will be much more resistant to safe-breaking tools and explosive than a less solid one. By making the door two or three feet thick the constructor of the strong room has ensured that any manipulation of the lock will have to be carried out at arm's length—assuming the unlikely event that the safe-breaker has succeeded in cutting a hole in the door. Obviously manipulation carried out at

full stretch of the arms cannot be as delicate and sensitive as would be the case if the safe-breaker could work at his ease.

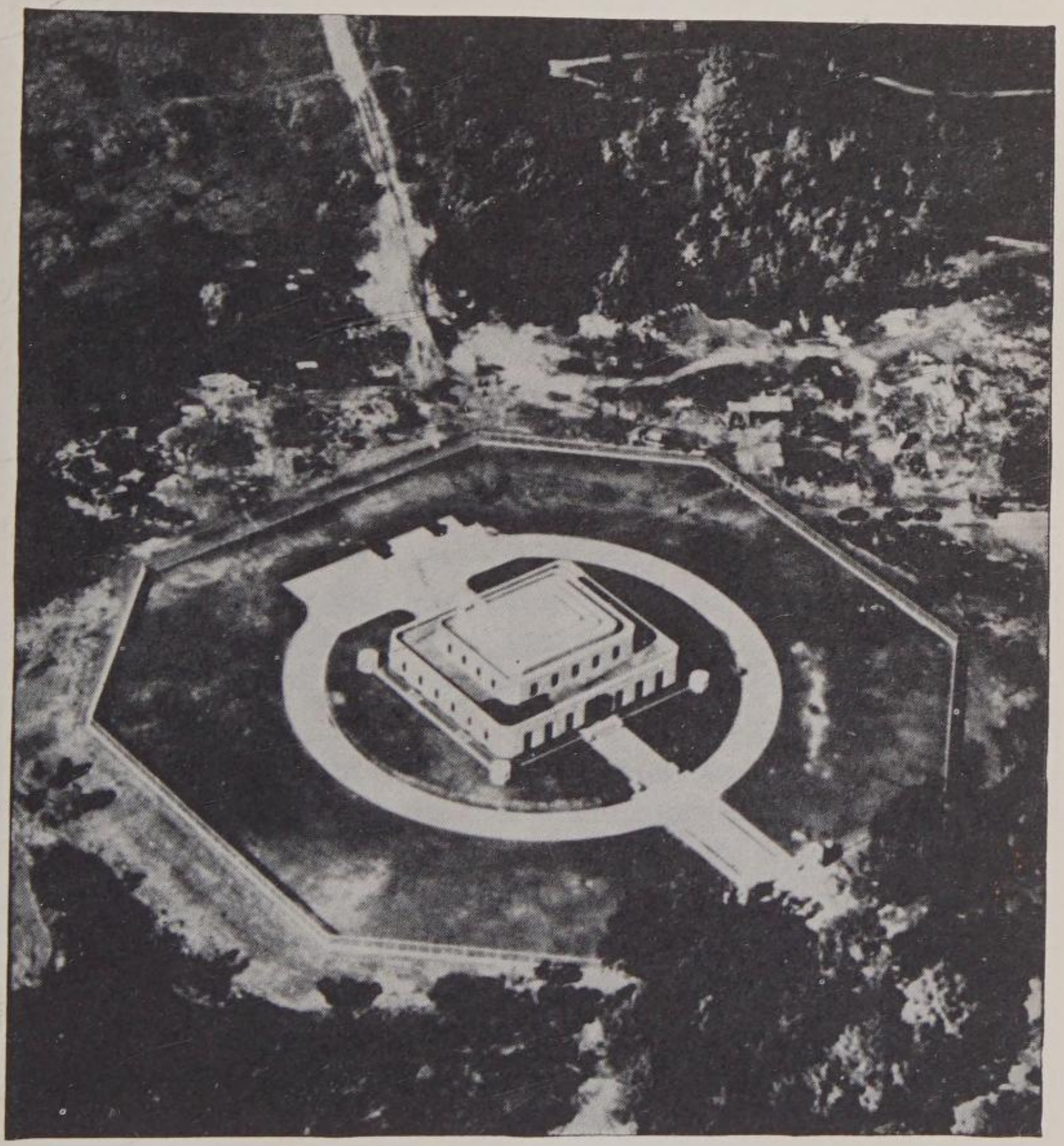
The doors are nearly always circular instead of being, as in most safes, rectangular. Generally speaking it is easier to achieve a perfect fit between two circular surfaces than between straight surfaces at an angle to one another. Often, too, the door is "rebated." This means that a cross-section of its edge would show a tapering zigzag pattern, each "zig" interlocking with the corresponding "zag" all the way from the outer to the inner edge of the door. More modern doors, however, are of the "plug" type. These possess extremely smooth tapering convex surfaces, polished like glass, that exactly fit the concave surfaces of the doorway. It is easier to machine a surface of this kind with absolute exactitude, and at the same time the extreme closeness of the fit offers even less of a gap for the safe-breaker's wedges than any other surface shape can provide. The safe-door maker works on another established principle: Every rebate is a reaction-seat against which explosives may work to tear the door apart.

The securest strong room in the world is undoubtedly the Bullion Depository at Fort Knox, in Kentucky, U.S.A. This contains something like $13 billion in gold—by far the largest deposit of bullion anywhere on earth. Not unnaturally this particular strong room was designed and constructed on the most elaborate and up-to-date lines, some of which are revolutionary. For instance, it is not concealed in the basement of a bank, but stands out boldly, in open country, visible from all directions (including the air).

The United States Treasury first selected a 30,000-acre reservation in a stretch of country almost ringed by the Appalachian Mountains. In the heart of this area the engineers built an outer ring of steel bars, which are perma-

The entrance to a Roman strong room at Chesters, on Hadrian's Wall.

An aerial view of the bullion vault at Fort Knox, Kentucky, the securest strong room in the world.



nently and powerfully electrified. Within this outer ring they built a massive steel-and-concrete structure, squat, low on the ground, bastioned with a blockhouse at each corner like a medieval fortress, the whole structure being about a hundred feet square. Within this massive structure is the vault itself, constructed partly above and partly below the level of the bedrock on which the depository itself is founded.

It is not often that details are given of the materials and quantities used, and the method of their use, in the case of strong rooms. Perhaps because it is confidently believed to be absolutely impregnable, being permanently guarded by a whole army of men, arms and vehicles, highly organized and trained and on duty all the time, Fort Knox has, however, been described in detail. No less than 4,200 cubic yards of concrete and 2,000 cubic feet of granite went into its construction, reinforced by no less than 1,450 tons of steel girders and bars. The steel plug-type door to the vault weighs no less than twenty tons, and its locking mechanism has been so devised that no single individual knows the whole combination.

The corridors surrounding the vault in which the gold is stored are fitted with mirrors so set that the guards have a two-way view along each corridor at whatever point they may happen to be, and it is physically impossible for them ever to be out of sight of one another, even momentarily. Water pipes have been installed so that in the event of a great emergency the entire building can be flooded. The door, and other points on the exterior of the vault, have been fitted with a secret invention that would emit a deadly poison-gas the instant that any flame-cutting equipment was brought to bear upon it. The whole building is alive with concealed photo-electric cells which make it literally impossible for anyone to take a step anywhere without its

being noted and recorded. It is small wonder that, so far as is known, no one has ever seriously contemplated organizing a bank robbery at Fort Knox; certainly no one could ever succeed.

Strong rooms, even in such important banks as the Bank of England, in London, and the Banque de France, in Paris, obviously do not need to be as elaborately equipped with burglar-proof devices. Nevertheless they do of course have auxiliary equipment designed for emergencies. Not only is there the fitted burglar alarm; there is also equipment designed to come to the aid of a bank official who unwittingly becomes locked into his own strong room. There is also the matter of lighting, and of ventilation.

The first is fairly straightforward. All major, and many smaller, banks are permanently linked to the nearest police station by remote-control electric alarm signal mechanisms, the "trembler" or some other reliable system. Usually, too, a strong room's doors are so equipped that a closing alarm gong is intermittently sounded during the process of locking up, so that anyone at work perhaps in a remote corner of a large strong room or safe-deposit will not be taken unawares and trapped overnight.

The electrical equipment has, however, to be devised for a wider range of use than that. It must, of course, illuminate the strong room adequately. It will have been designed so as to operate automatically as soon as the door mechanism is set in motion, and automatically switched off when the door is finally locked for the night or the weekend. But there is always the small risk of a power-cut, either through the power station or through lightning, and therefore, as in a hospital, an auxiliary lighting system must be installed and so designed that it automatically comes into operation immediately the main source of light and power fails, for whatever reason.

In addition to this it is not unusual to have one small lamp burning at all times, whether or not the main or auxiliary lighting system is in operation. This is so that, in the extremely unlikely event of a bank official being trapped in a strong room and then finding the lights automatically switched off, he can still read the printed instructions posted for dealing with just such an emergency as this. The instructions will include the home telephone numbers of certain of the bank staff, and also explain how to disconnect the time-locking device from inside the strong room and make other preparations for his own release.

No less important than a foolproof lighting system is, of course, ventilation. Under normal conditions the average individual can live fairly comfortably on about one hundred cubic feet of air per hour. That is to say, he should be able to breathe reasonably well for an hour in a room four feet wide by four feet long and six feet high. However, when anyone is in a state of anxiety or fear—such as may well be induced by finding oneself shut in somewhere without means of escape, the normal intake of air is considerably increased, because the person begins to breathe both more rapidly and more deeply. As a precautionary measure, therefore, many of the larger strong rooms and vaults are equipped with one or other of several devices for eliminating the risk and fear of suffocation.

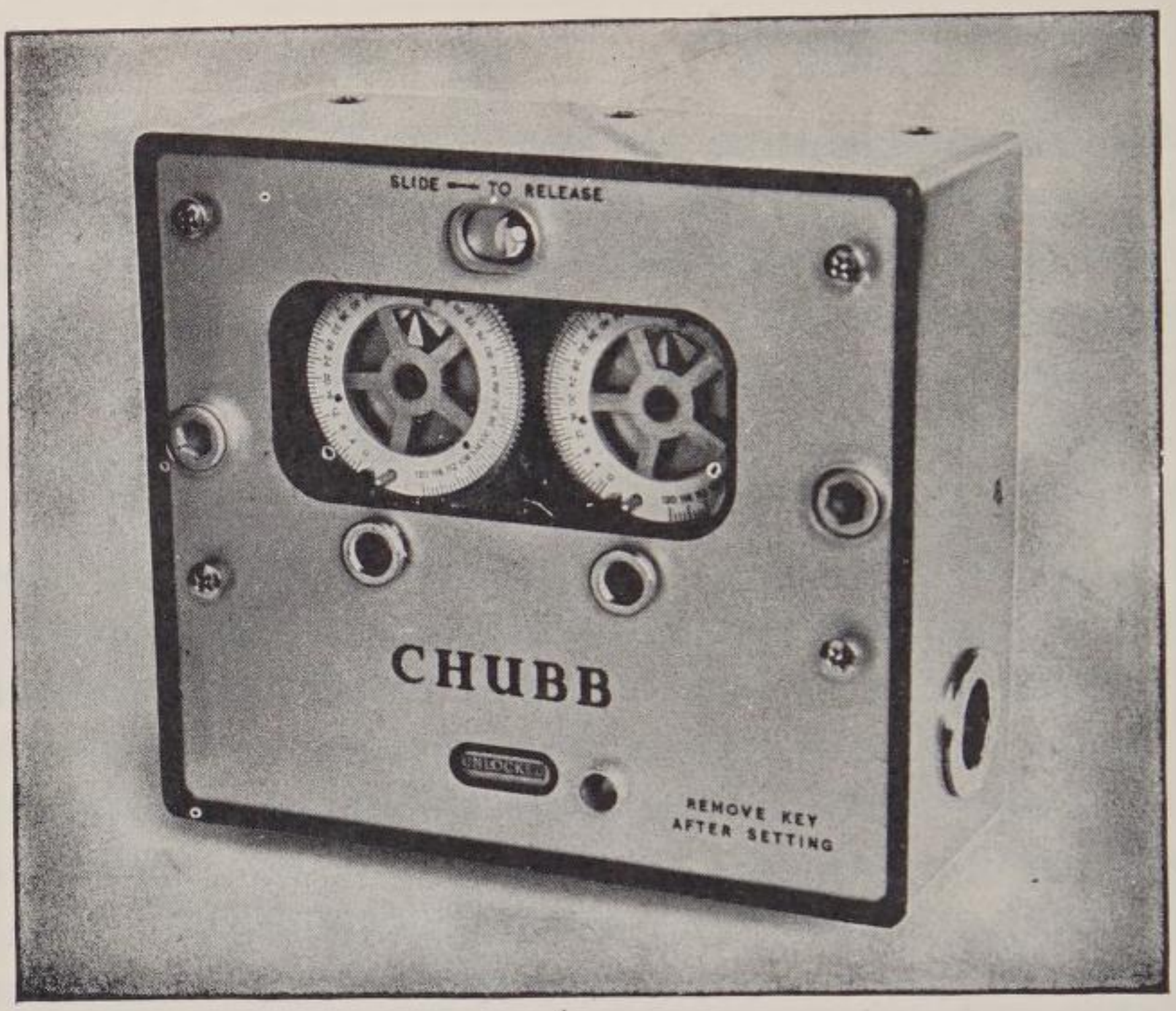
In some of these a breathing-tube is used. This is permanently installed and takes the form of a duct about the size of a brick as seen end-on—four inches or so by three. One end of this duct is in freely circulating air outside the premises; the other, which of course is in the strong room itself, is furnished with a removable plug. Where the distance between the two ends of the duct is considerable, very often a small suction-fan is incorporated, and removal of the plug at the inner end sets this in motion so that

fresh air is automatically and continuously pumped through to the temporary prisoner. An alternative system is to have oxygen tanks installed, with clear instructions as to the operation of their valves and the quantity to be released. There may also be a supply of chemical for spraying on the floor in order to absorb or neutralize the accumulated carbon dioxide.

The latest development in security is the "time" lock, which is used in conjunction with combination and sometimes other locks. It may be said to be the master of them all. For though in the strict sense it is not a lock at all, it is the mechanical guardian over the locks, incorruptible, unpickable, unsleeping. Very briefly, it is a device for ensuring that no one, not even the chief cashier or bank manager himself, not even the manufacturer of the safe or his expert lockpickers, can open it except at a predetermined hour and minute.

The earliest known time lock, a highly experimental object, was devised by a Scot more than a century ago, a man named William Rutherford. It consisted of a disk with a notch in it, operated by a clockwork mechanism behind it in such a way that not until the notch reached a certain predetermined point on the clock face could access be gained to the lock mechanism itself. The mechanism was actuated by springs when it was attached to a safe small enough to be picked up and carried away; by weight-and-pendulum, like the mechanism of a grandfather clock, in the case of heavier safes.

The modern time lock is simply an elaboration on this basic principle. To begin with, the "clock" element has to be a precision instrument possessing the extreme accuracy of a ship's chronometer. Further, its movement will almost certainly be in duplicate at least, and very often in triplicate. This is so that in the event of one clock running down,



A five-day, two-movement time lock. The mechanism is duplicated for additional security for the strong-room door or safe to which it is fitted.

or developing some mechanical fault, there will still be a second clock functioning. The third clock is installed so that if one clock has to be removed for cleaning, adjustment or repair, there will still be a second clock at work and a third clock acting as double security behind that.

The method of utilizing the time clock is straightforward enough. The chief cashier, or bank or other official responsible for opening the strong room each morning, sets the time clock so that it will operate at the exact hour and minute at which he intends to open the strong room on the following morning. Or, when a weekend or other holiday intervenes, for the exact hour and minute on the next morning when the bank is to open. All time clocks are designed to run for a minimum of seventy-two hours, and

many have mechanisms that enable them to keep running for anything up to ninety-six or even a hundred and twenty hours, so that even the most unusual and unexpected circumstances do not throw the system out of gear.

A time lock is an "absolute." The strong room which it guards cannot be opened by anyone at all until the predetermined hour is reached. The chief cashier, though he has set the combination lock himself and knows the exact arrangement of the digit groups, is as powerless as a child would be. The unauthorized lockpicker, however great his skill, however well supplied he may be with false keys, can do nothing with the lock (apart from forcing it with explosives) until, as it were, the time lock gives him permission.

The time lock was brought into use in America after there had been a wave of crimes in which the procedure had been to get hold of the chief cashier and, by threats and sometimes even torture, to extract from him the combination figures. No cashier, however honest, loyal and courageous could be expected to withstand torture just to prevent the entering of his firm's strong room. But when it became generally known in the underworld that even the bankers themselves could not gain entry to their own strong rooms until the predetermined hour, and that when they did so they would naturally have assistance within easy call, it was realized that it was no use continuing the hideous practice that had served so well for so many years.

In association with a good combination lock, a time lock offers the ultimate in security. A good chronometer is as nearly perfect as any piece of mechanism can be; when it is installed in duplicate, or in triplicate, the risk that anything could go wrong becomes infinitesimal. If it is asked, What happens when for some reason the chief cashier arrives late, past the time at which he has set the clocks?

the answer is that they all have a margin of anything up to three-quarters of an hour or so beyond the predetermined hour, and this is a margin that permits other steps to be taken. In any case, at worst it simply means that the strong room will remain secured for exactly twenty-four, or forty-eight or seventy-two hours longer.

Being such an elaborate and highly-perfected piece of mechanism, the time lock is necessarily extremely expensive, and is therefore installed only when considerable sums of money or quantities of valuables have to be guaranteed the maximum degree of security. This it certainly offers. Its mechanism is a beautiful example of the clockmaker-locksmith's skill and ingenuity.

A system of bars, levers, dials, notches, springs, weights, ratchets-and-pawls and other devices, actuated and controlled by constant-tension springs and barrels, makes sure that the true locking mechanism is utterly locked until the exact moment predetermined for the release of the bolts. To watch one of them in operation is to be struck by the uncanny, human-like element of the small, finely machined parts which seem to think for themselves and to act of their own carefully self-controlled volition. And all the time there is the additional and comforting fact that machines are not subject to mortal frailties: they do not oversleep in the morning, catch colds and chills, become forgetful, or get lured away from the straight path by temptation; they are always on guard, punctual to the second, incorruptible in their integrity!

Four thousand years lie between the first known locks—the Egyptian pin-tumbler locks of the days of the Pharaohs—and the modern counterparts in universal use today; the detector lever locks, the combination locks, and the magical time locks. All down the ages the ingenuity of man has

been devoted to the problem of achieving security against the evil-doer. When Shakespeare made Shylock remark

"Fast Bind, Fast Find:
A proverb never stale in thrifty mind"

he was, as so often, putting the whole problem into the proverbial nutshell.

It is perhaps to be regretted that so much ingenuity, so much craftsmanship and inherited, accumulated skill, should have had to be expended throughout the world and over such an immense span of time, with this one end in view: that of safeguarding property against malefactors. But so it is; and it seems unlikely that the time will ever come when property is so universally owned that no one will feel it worth his while to lock it up in order to keep other people's hands off it.

In one small sphere, however—that of locks, bolts and bars—it does seem that perfection has at last been attained. Scientists and inventors will doubtless continue their indefatigable search for bigger and better bombs, for faster and faster spaceships—objects which neither the Egyptians nor the Greeks nor the Romans nor the ancient Chinese bothered about too much. But the locks and keys devised for us in this modern age serve their purpose as well as the old pin-tumblers, the sickle-keys and other gadgets served our ancestors, and it hardly looks as though there is even one more chapter to be written on the subject.

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